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Frank Watson Dyson
1868-1939

By FRANK SCHLESINGER

Most American astronomers first became acquainted with Dyson in 1910 when he came to this country primarily to attend the third meeting of the International Solar Union, held at Pasadena in connection with the dedication of the Mount Wilson Observatory. This meeting was preceded, by some two weeks, by one of the American Astronomical Society (then only a dozen years of age) held at Harvard College Observatory. This was attended by a goodly number of the delegates to the Pasadena meeting and after its close many of us boarded two special Pullman cars that made a leisurely journey across the continent with stops at Niagara Falls, Chicago, the Grand Canyon, and Flagstaff. We were thus in each others' company without interruption for two solid weeks and the opportunity for getting well acquainted with each other was unexcelled. Dyson began this journey as Astronomer Royal for Scotland and Professor at the University of Edinburgh; he ended it as the ninth Astronomer Royal of England, for somewhere on this journey he received a cablegram informing him of his appointment to this honorable post in succession to Sir William Christie.

Dyson was born in northern England on January 9, 1868, the son of Watson Dyson, a Baptist minister. At school he displayed marked mathematical ability and won a scholarship at Trinity College, Cambridge, the cradle of so many notables in the mathematical world. He was graduated B.A. in 1889, remaining at Cambridge as fellow until 1894 when he was appointed Chief Assistant at Greenwich under Christie. Then as now it was the custom at Trinity to look after the mathematical equipment of its students without paying much attention to what application they intended to make of it. But Dyson early showed his preference for astronomy and began publishing papers in this science while still at Cambridge.

At Greenwich the first great task that devolved upon him was to get out the zone of the Astrographic Catalogue for which the observatory had agreed, in 1887, to be responsible, that between declinations $+65°$ and $+90°$. This he accomplished in model style; the Greenwich Zone was not only the first to appear, but it is admirable for completeness, form, and accuracy. This work undoubtedly formed Dyson's bent for proper motions and a good deal of his life's activity was devoted to accumulating and discussing data of that kind, beginning (in collaboration

with W. G. Thackeray) with a new reduction of Groombridge's Catalogue, the observations for which were made around 1810. These positions supplemented in a very desirable way those of Bradley (1760), referring as they did to much fainter stars and first making possible the extension of Kapteyn's two-stream discovery to stars as faint as the ninth magnitude.

In 1905 Dyson was appointed Astronomer Royal for Scotland, a post he was to occupy for only five years before he returned to Greenwich as Astronomer Royal. Here he remained until his retirement in 1933.

These twenty-three years proved to be among the most fruitful in the long and honorable history of Greenwich Observatory. This institution was founded in 1675 for the express purpose of aiding navigators by the accurate observation of the sun, the moon, and the stars, and for more than two centuries this purpose was rather rigidly adhered to by the successive staffs; at least their efforts were almost exclusively confined to astronomy of position. Dyson was the first Astronomer Royal to break away from this tradition, introducing astrophysical researches into the regular work of the observatory.

In another respect, too, Dyson set up an important reform. Sir George Airy, who was seventh Astronomer Royal during the extraordinarily long interval extending from 1835 to 1881, introduced early in his administration a new policy in the making of observations. He believed that only two or three well-trained astronomers were necessary at Greenwich and that the other members of the staff need only be drilled in doing well a set task. There is no doubt that this policy, which was continued by his successor, was at least partially successful and that a great number of accurate observations flowed from Greenwich during a long term of years. But this plan is obviously one that does not lead to the cultivation of new ideas or to improvements in methods, and when Dyson assumed office Greenwich had fallen behind in these respects. He at once made a radical change, encouraging the members of his staff to undertake new kinds of research, awakening their enthusiasm and otherwise helping them to carry out this new work. The effect was very striking, Greenwich at once resuming its position among the leading observatories of the world in every sense. This was accomplished without any great changes in the staff, some of whom have taken their places among the important contributors to our science.

Dyson was one of the most modest of men, and modest not merely so far as word of mouth is concerned but in a deeper sense. One could not judge even from intimate association with him, how thoroughly he was acquainted with the details of the observatory's work and how large a share he had in its inception and its progress. It was only upon becoming acquainted with the various members of his staff, and hearing their affectionate and admiring testimony that one could realize how great a part he played in all the work of the observatory.

These activities and the administrative duties that inevitably devolve

upon the head of a great observatory did not prevent Dyson from issuing under his own name a goodly number of papers dealing largely with fundamental astronomy and particularly with stellar motions. He organized and accompanied many eclipse expeditions and was invariably favored with good weather. In 1918 while the war was still in progress he urged the observation of the 1919 eclipse to test the effect predicted by Einstein, and succeeded in fitting out two expeditions to eastern South America and western Africa. These parties secured the first observations confirming this effect, a result that has been since amply verified by other observatories.

Dyson's home life was especially happy. Early in his twenties he married Caroline Best, the daughter of the physician Palemon Best; two sons and six daughters blessed this marriage and filled the Flamsteed House at Greenwich with joyful sounds. Lady Dyson died in the spring of 1937, a blow from which he recovered with difficulty. Another blow that stunned him, as a patriotic and proud Britisher, was the Munich agreement. But his death on May 25 of this year came as a complete surprise to his many American friends. He died at sea of a heart attack on the way from the home of one of his children in Australia to that of another in South Africa.

Throughout their lives he and his wife were deeply interested in many social projects that centered around Greenwich. The working class of that district will sadly miss them, as indeed will every one who had the good luck to enjoy acquaintance with these two noble souls.

YALE UNIVERSITY OBSERVATORY, 1939 OCTOBER 16.

A Preliminary Report on Fireballs Observed in Southern Sweden on May 27, 1938*

By AXEL CORLIN

On the evening of May 27, 1938, the author was told by a local newspaper office that many persons had just observed a very bright fireball moving from west to east. The observations were made at about $18^h\ 30^m$ G.M.T. in a wholly clear sky, and, inasmuch as the sunset took place at $19^h\ 29^m$, the sun was still above the horizon at an altitude of 7°. The fireball was said to be several times as bright as the moon.

The author immediately asked the telegraphic bureau of the Swedish Associated Daily Press to send out a request, in all Swedish and Danish newspapers, for observations of the fireball. Later on this request was extended also to German and English newspapers. As a result of

*Communicated by Dr. Frederick C. Leonard, Editor, THE SOCIETY FOR RESEARCH ON METEORITES.

this widely published request, within a fortnight not less than 554 reports arrived at the Observatory of Lund. Of these, 548 dealt with the fireball display on the evening of May 27. However, of these, only 12 were from Denmark, and these 12 were exclusively from Copenhagen, while only 2 were from Germany, and the rest, or 534, from Sweden. The observers were geographically distributed from about the $+55°$ parallel (fishermen in the Southern Baltic) to Dalecarlia and the surroundings of Stockholm at about the $+60°$ parallel, and from Copenhagen in the west to Gotland in the east. Thus the area from which the fireballs were reported was 600 km. in the N.-S. direction, and 370 km. in the W.-E. Subsequently, when visiting many places within this area, I was told about a good many persons who also had seen the fireball but had not reported their observations to this Observatory. It seems likely that several thousand people saw the phenomenon. This circumstance is perhaps somewhat remarkable, because the sky was very bright, and the duration of the phenomenon, at most, was certainly only some ten seconds.

At least 500 observers were immediately asked by mimeographed letters to send further details concerning the direction, the exact time, *etc.*, of the phenomenon, and about half of these responded. For 249 observations, it has been possible to derive more or less reliable azimuths and altitudes of the beginning and the end of the apparent tracks. Even the preliminary reports indicated groups of rather different directions and times for the phenomenon. The *time-points* extended over a range of more than two hours, even in those cases where the watch-readings were checked by radio signals or in some other convincing way. In order to collect data as accurate as possible for a determination of the character of the phenomenon some automobile expeditions were sent out from the Observatory at Lund to the different observers. Azimuth and altitudes were then remeasured with compass and theodolite. For economical and other reasons, this program could not be realized to the extent originally planned. It is to be regretted that the measurements, which began in Scania, or the most southern part of Sweden, and were planned to extend farther, had to stop before they reached those eastern parts of southern Sweden, where the directions were in most cases nearly at right angles to those measured in Scania. However, 88 observations were checked in this way, and these together with some 13 similar measurements made spontaneously by the observers themselves, make a total of 101 comparatively accurate directions, giving the beginning and the end of the apparent tracks. If only one fireball had fallen this evening, such material would, of course, be sufficient for determining the track, but, as will be seen hereafter, there were certainly several fireballs, often very difficult to identify.

At present the material has been investigated in a qualitative way, and some of the statistical results may be interesting. Of the 548 observations of this evening, 170 give the time of observation to the nearest min-

ute, but only 45 of them are known by me to have been checked, *e.g.*, by comparison of the time keepers with broadcast signals, railway clocks, or other official clocks. 109 observers saw an explosion at the end of the *track*. Further, 45 saw partitions of the fireball into two or three parts, or many sparks; in addition, some 11 saw a partition into *dark* bodies as mentioned hereafter. Nobody heard any thunder from the explosion, but 33 observers heard a hissing noise when the fireball was passing, and of these, 12, who were facing another direction from that in which the fireball appeared, heard the noise first, turned round, and then saw the fireball. 85 estimated the time of duration of the phenomenon; 50 saw sparks from the tail during the motion of the fireball; 164 mentioned the form of the tail. This latter circumstance makes it possible to study the types of the tails. Many observers described the light of the fireball to have been as sharp as that of a welding flame and rather hard for the eye to sustain.

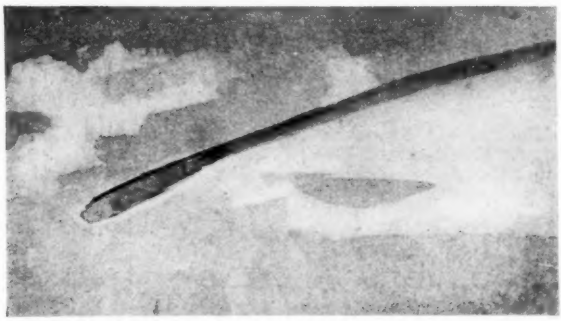


FIGURE 1
FIREBALL WITH TAIL OF TYPE *A*,
according to a water-color painting by the observer No. 561, the artist, Mr. *J. Sjöstrand*, Kalmar. Mr. *Sjöstrand* was busy painting the island of Öland as seen from the town Kalmar on the east coast of Sweden. In the course of his work, the fireball suddenly appeared at $18^h\,40^m$ G.M.T., and Mr. *Sjöstrand* put the fireball with correct colors into his painting, which was kindly sent to the Observatory of Lund. The upper boundary of the phenomenon was dark, and the nucleus was white. Nearest to the nucleus the tail was yellow, then red, then green, and finally blue, and ended in a strip of dark smoke.

There seem to have been at least four rather different types of tails, *to-wit*: (1) Type *A* (Figure 1): A long tail, usually about the breadth of the fireball (81 observations); (2) type *B* (Fig. 2): a fan-shaped tail of separate flames almost always yellow in color and with markedly increasing width backwards (12 observations, belonging probably to the same fireball); (3) type *C* (Fig. 3): a short tail ending in a peak and making the whole appearance like a comet with the front side broad (44 observations); and (4) type *D* (Fig. 4): a nucleus like a

FIGURE 2

FIREBALL SHOWING TAIL OF TYPE *B*, as drawn by observer No. 244, Mr. *Th. Bune*, Gislöv, Eastern Scania.

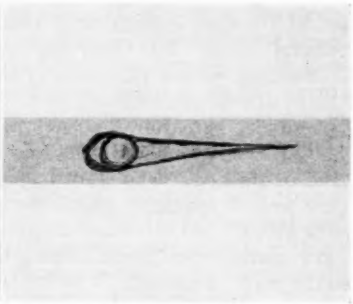


FIGURE 3

FIREBALL SHOWING TAIL OF TYPE *C*, as drawn by observer No. 323, Mr. *C. Nilsson*, Strandbaden, Western Scania.

FIGURE 4

FIREBALL SHOWING NUCLEUS AND TAIL OF TYPE *D*, as drawn by observer No. 556, Mr. *W. J. Hamilton-Clausen*, Copenhagen, Denmark.

drop, a pear, or an electric lamp with a very narrow and faint tail (19 observations). In addition, there are some 8 observations of a fireball which is said to have been like a "Zeppelin airliner," of a silver or aluminum color (type *E*). Neglecting here the distant most northern observations, I have divided the rest of the material into four zones from west to east, and in Table I the observations of different characteristics are collected and expressed as percentages of the total number of observations in these zones (*N*). Here "long tails" are those only of type *A*, and "short tails" are those of types *C* and *D*. The column "vanished" gives the percentages of those observations which reported that the fireball vanished in the sky above the horizon and without explosion. The other columns are self-explanatory.

TABLE I[1]

How Different Characteristics Varied from West to East
(The frequencies are given as percentages of *N*.)

Zone	*N*	Long tail	Short tail	Ratio	Vanished	Explosion	Partition
Western Outer Zone	111	8.1	16.2	0.5	8.1	14.4	3.6
Western Inner Zone	130	8.5	16.9	0.5	7.7	20.0	6.2
Eastern Inner Zone	132	19.7	9.8	2.0	1.5	24.2	6.8
Eastern Outer Zone	106	20.8	3.8	5.5	3.8	30.2	22.6

[1] The first zone comprises Copenhagen, the province Western (Skåne) Scania, and Halland; the second, Middle Skåne and Western Småland; the third, Eastern Skåne, Western Blekinge, and Middle Småland; the fourth, Middle and Eastern Blekinge, Eastern Småland, and the islands Öland and Gotland.

It is seen that the number of observations mentioning a long tail increased markedly from west to east, *i.e.*, in the direction of motion of the fireball, whereas the number of short tails diminished in a similar way. The number of disappearances in the sky above the horizon also decreased markedly towards the east, whereas the number of explosions, and especially partitions, increased.

A statistical analysis of the estimates of the duration of the phenomenon is given in Table II. Inasmuch as the number of such estimates is rather small, the two western and the two eastern zones have been taken together. The main result of the table is that the most frequent estimates

TABLE II

Estimates of the Duration: Numbers

Seconds	0-2	3-5	6-8	9-11	12-14	15-17	18-20	>20	Total
Western Zones	11	12	4	7	4	1	—	5	44
Eastern Zones	1	11	5	4	1	3	1	7	33
	12	23	9	11	5	4	1	12	77

are between 3^s and 5^s. Neglecting the estimates greater than 20^s, which are given mainly as a half or a whole minute, and which are, perhaps, rough over-estimates, we find the mean duration of the western zones to have been $5^s.8$ and the mean duration of the eastern zones to have been $7^s.7$. Whether this difference indicates a breaking up of the fireballs to-

wards the east is, of course, very doubtful. Only 3 observers seem to have have counted directly the seconds during the appearance and found 2, 3, and 6 seconds, respectively.

As mentioned previously, the material makes it very probable that several fireballs appeared on the evening of May 27. Although we agree with the suspicion that even those reported times of the phenomenon which are reputed to have been checked, may be in error by several minutes, still, it seems hardly possible to deny the existence of fireballs at rather different times as indicated by the reported checked times. Their frequency is given in Table III. At the end of the table are collected

TABLE III

FREQUENCY OF CHECKED TIMES

G.M.T.	*N*	G.M.T.	*N*
$18^h\ 23^m$	1	$18^h\ 40^m$	12
18 26	1	18 41	6
18 30	1	18 42	3
18 32	2	18 44	1
18 36	2	19 05	1
18 37	2		
18 38	3	18 00-14^m	2
18 39	9	20 00-15	4

some observations of not exactly known time, but apparently not to be confused with the other times. It is seen that the maximum frequency of the checked times of observation (as well as that of the unchecked ones) occurs at $18^h\ 40^m$ G.M.T., while between 39 and 41^m there are 27 given as exact times, which, of course, may have been confused in several cases. But the observation at, *e.g.*, $18^h\ 23^m$ G.M.T., can hardly be related to the fireball, or fireballs, observed at $18^h\ 40^m$. This observation was made by a farmer and his wife, who immediately read a radio-checked watch and marked their place of observation by a peg. They were later visited by me and found to be educated and perfectly reliable persons. In addition, there are some unchecked times at about this minute. Similarly, the single time at $19^h\ 05^m$ was determined by two ladies residing in a town in central Sweden, who immediately compared their watches with a clock situated on an official building, visible from their place of observation. Many of the other reporters of checked times were civil engineers, teachers, or other educated people, who paid great attention to the control of their watch-readings. One of the observations, at a not very accurate time between $18^h\ 00^m$ and $18^h\ 14^m$, was made simultaneously with the program of the Swedish broadcasting Company, between $18^h\ 00^m$ and about $18^h\ 10^m$, and the other was published in the *Astr. Nach.*, **255**, Nr. 6363, as made in Danzig. Of the 4 observations at about or shortly after 20^h, 3 were made either in Gotland or on the eastern coast of the Swedish mainland opposite Gotland.

Moreover, the observation at $18^h\ 26^m$, made in northern Småland, converges as to the end direction with a few others *of about the same time* at a point (Group *X*) : long. E. 15° 23′, lat. +57° 25′, or just east

of the municipality of Vetlanda in northeastern Småland, far from the convergence points of the other investigated observations (*cf.* Fig. 5). 6 of the 9 observations at controlled time $18^h\,39^m$ converge within a circle of radius only 14 km. (Group *R*, Fig. 5), around long. E. 16° 41′, lat. +55° 44′, or 62 km. south of the southern extremity of Öland, in the southern Baltic. 4 of the 6 observations at checked time $18^h\,41^m$ converge within a circle of 10 km. radius at long. E. 16° 11′, lat. +56° 12′ (Group *V*), or just between the southern extremity of Öland and the Swedish mainland, and about 75 km. north of the convergence point *R*. The 3 observations at the checked time $18^h\,42^m$ converge within a circle of some few km. radius at long. E. 16° 35′, lat. +55° 0′ (Group *Z*), or 95 km. east of Bornholm and 75 km. south of point *R*, not far from the coast of Germany at Stolp. 3 observations made shortly after 20^h indicated a convergence point (Group *Y*) northeast of Gotland, or at about long. E. 19° 30′, lat. +58° 20′, near the island Gotska Sandön. The most frequent observations at the time around $18^h\,40^m$ G.M.T. showed a more complicated behavior, as mentioned hereafter.

Furthermore, there are 6 reports of 2 fireballs seen either shortly after each other by the same observer or noted by another observer in the surroundings of the first one, considerably earlier or later. Here a short summarization is given of these reports:

No. 522. The Teacher, *P. Ljungberg*, Osby, (E. 14° 0′, +56° 23′). At about $18^h\,40^m$ G.M.T., he saw 2 strongly shining spheres in the sky moving from west to east in a direction given on a map. The latter took place at most 30^s after the first one and exploded in a rain of sparks. The exact time was not noted, because the observer thought at first that the fireballs were two rockets, sent out perhaps from an airplane which simultaneously was circling in the air. Later on, Mr. Ljungberg collected several observations from other persons who also had seen the fireballs. Some of these observations were made when the airplane moved northwards, others when it was moving southwards.

No. 140. The Engineer, *E. Gunnarsson*, Klintehamn on Gotland. He was driving a car, and arrived at a point long. E. 18° 31′.5, lat. +57° 42′, when he suddenly saw a bright light in the sky like that from a just-disappearing meteor. He stopped the car and pointed out the phenomenon to his companion. A few seconds later the two gentlemen saw a second meteor in about the same direction as the first one. At the beginning this meteor appeared as "a 3rd magnitude star" and increased to a fireball, which exploded in a swarm of sparks. The watches were immediately read as $18^h\,43^m$ - $18^h\,44^m$ G.M.T., the azimuths, altitudes, colors, apparent size, and duration were estimated, and a perfect observational report was sent to the Observatory of Lund.

No. 375. The Teacher, *K. Öborn*, Stockaryd (E. 14° 35′.5, +57° 19′). At exactly $18^h\,40^m$, as immediately read from his watch, he observed a fireball with a yellow head and a green tail of type *C* moving towards the S.E. Later on, he was informed that several reliable persons at this

place had observed another fireball about 10^m later, moving higher in the sky and more towards the south.

No. 349. The Lighthousekeeper, *J. Lagerwall,* at Utklippans Lighthouse in the Baltic (E. 15° 42′.5, +55° 57′), saw at $18^h\,40^m$, a long and brightly shining phenomenon rapidly moving from the S. to the S.E. and disappearing above the sea-level without exploding. Other persons at the same lighthouse saw, about 20^m later, another meteor in the E.N.E.

No. 286. Mrs. *E. Carlsson,* Påskallavik, on the eastern coast of Sweden (E. 16° 26′, +57° 10′), saw, at about $18^h\,35^m$, a fireball moving towards the S., rather low in the sky. A few hours later she met her husband, and he told her that he had seen another fireball at about 20^h high in the sky and moving towards the N.N.E.

No. 488. The Teacher, *H. Stengård,* Hemse on Gotland (E. 18° 22′.5, +57° 14′.5), did not see the fireball, or fireballs, which were observed at about $18^h\,40^m$ by many persons in his surroundings as they reported to him. But he himself saw later, at $20^h\,12^m$ G.M.T., another fireball moving E. of Gotland from the S. to the N.N.E. This fireball fell slowly, was white in color, and was accompanied by several smaller, white "fireballs" forming something like a tail of the large fireball.

These observations seem to indicate without doubt that several fireballs occurred on the evening of May 27. Nevertheless, it must be admitted, that, if there was a general train of fireballs on that evening, only 6, of 550 observations reporting 2 fireballs is a rather low percentage. Moreover, the controlled times may be in error. Having met much skepticism as to the occurrence of several fireballs on this evening —albeit from persons who have not studied the material—I found it desirable to study the question also from other points of view. Thus, I neglected the differences as to the *time-points,* whether controlled or not, and collected the directions of the explosions. Among the reports of explosions were 11 stating that the nucleus was quite dark just before the explosion and that dark fragments were thrown out at the explosion. For 8 of these observations, the direction was derived, and *all 8* directions converge within the previously mentioned circle of radius 14 km. around point *R* in the Baltic (*cf.* Fig. 5). 3 of these observations had a controlled time of $18^h\,39^m$, and, as mentioned previously, still 3 of controlled time $18^h\,39^m$ converge within the same small circle. Of the latter 3, 2 were made very far away, namely in Halland in the western outer zone and in northwestern Småland. In the first case the fireball disappeared behind a hill elevated 12° above the horizon, and in the third observation the fireball disappeared behind a house. Therefore, the explosion and the dark fragments could not be seen, perhaps, in these 3 cases. At any rate, the convergence of all the 8 directions of a "dark explosion"and of 6 controlled times at $18^h\,39^m$ within the small circle mentioned seemed to encourage the possibility of identifying a certain fireball. There is only one ambiguity concerning this agreement, *viz.*:

one of the "dark-fragment observations" had a checked time of $18^h\,42^m$ and its direction to the explosion goes from Öland through the circle of R farther towards the point Z (*cf.* Fig. 5), where it converges very well with 2 other directions of controlled time $18^h\,42^m$. Therefore, either this time is incorrect to the extent of 3 minutes, or the fireball at Z ejected perhaps also dark fragments. In fact, the fireball that exploded at Z at $18^h\,42^m$ was characterized by dark smoke seen immediately after the explosion as mentioned hereafter.

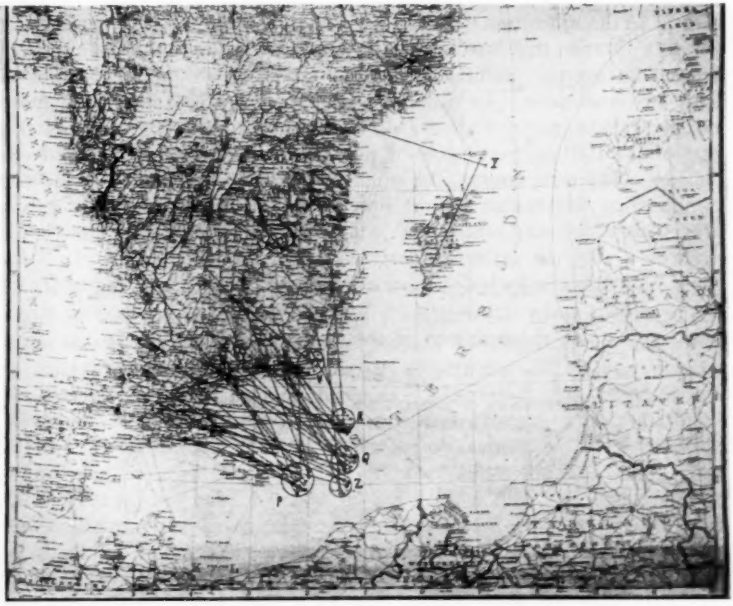


FIGURE 5

A MAP OF SOUTHERN SWEDEN AND THE SOUTHERN BALTIC, WITH SURROUNDING COASTS, SHOWING THE CONVERGENCE POINTS *P*, *Q*, *R*, *V*, *X*, AND *Y*.

Only a few directions have been drawn in the map, namely those which are tentively ascribed to the convergence points and, in addition, point out an explosion or are connected with checked times. A double arrow at the end indicates a direction as measured with compass; a single arrow, a direction as given by the observer on a map. It may be noted that the corresponding different fireballs appeared at different times. Thus X appeared at $18^h\,26^m$ G.M.T.; R, at $18^h\,39^m$; P and Q, at $18^h\,40^m$; V at $18^h\,41^m$; Z at $18^h\,42^m$; and Y at $20^h\,12^m$ G.M.T.

Proceeding then to the other directions of explosions it appeared that they formed two rich bundles converging at 2 separate points P and Q (Fig. 5) situated 65 km. from each other and being on both sides of Z. Thus, 14 "explosions" were found to converge within a circle of radius 20 km. around P at long. E. 15° 49′, lat. +55° 4′, and 15 "explosions"

converged within a circle of 15 km. radius around Q at long. E. 16° 45′, lat. +55° 14′.5, both points situated in the Baltic, east of the island of Bornholm. In both groups there are, however, very few observations with a checked time, namely only 2 of $18^h\,40^m$ in Q and only one of $18^h\,40^m$, and one of $18^h\,41^m$ in P. Further, 5 "explosions" go between them towards Z; of these, only 3 have been measured, however, with compass. Of course it is easy to suppose that all 34 directions reflected only one explosion of a single fireball, instead of the 3, P, Z, and Q, and that their apparent dispersion was due to errors, especially if we disregard the indication that Z occurred at $18^h\,42^m$ and P and Q at $18^h\,40^m$. But in this case we should expect that the directions crowded around an average point and did not show maximum frequencies at both extreme sides. In order to study this feature somewhat more closely, I have mapped all the directions at hand, going towards this part of the Baltic, irrespective of time and explosion or absence of explosion. Then, of course, the number is considerably larger, and the complication occurs that several directions, which pass through, *e.g.*, the previously mentioned circle of P, continue, when extended, through the circle of Z also, the latter circle having a radius of 15 km. In such cases I have at first included these directions in both P and Z (or Q and Z), as shown in the upper part of Table IV, and then omitted all directions which pass through two of the circles P, Z, and Q. In the latter

TABLE IV

FREQUENCY OF DIRECTIONS TOWARDS P AND Q AND INTERMEDIATE TO THEM (Z)

Directions	P	Z	Q
Measured	33	25	24
Not measured	25	12	28
Total:	58	37	52
Measured	16	8	22
Not measured	20	7	16
Total:	36	15	38

case I counted only those directions which go through one of the circles P and Q alone, or between them alone, as shown in the lower part of Table IV. This table exhibits the results. Here "measured" means those directions which were measured with compass and "not measured" means those as given by the observers on maps.

It is seen that, irrespective of how the material may be grouped together, there is an obvious concentration towards P and Q. Comparatively few directions between them point towards Z. Perhaps all of the latter were due to a third fireball which occurred 2^m later, as indicated by all the 3 known directions of checked time $18^h\,42^m$ converging towards Z. Hence it seems probable that there were 2 fireballs here at $18^h\,40^m$, namely P and Q. This conclusion is strengthened, perhaps, by the fact that the direction to the end-points of the 2 fireballs seen almost

simultaneously by the observer No. 522, *P. Ljungberg* in Osby, quoted previously, just passes between *P* and *Q*.

The "convergence circles" around *P*, *Z*, *Q*, and *R* exhaust rather completely the numerous directions going towards the southeastern part of the Baltic. Thus 42 directions have been collected as group *P* (18^h 40^m), 17 as group *Z* (18^h 42^m), 39 as *Q* (18^h 40^m), and 21 as *R* (18^h 39^m). For each group the reports as to the color of the nucleus, the type of the tail, and other characteristics, were collected for a comparative study, and the results are seen in Table V.

TABLE V

Characteristics	*P*	*Z*	*Q*	*R*
Bluewhite Nucleus	7	1	6	3
White Nucleus	7	5	0	3
Yellow Nucleus	5	4	6	3
Red Nucleus	6	0	0	0
Tail Type *A*	4	1	7	4
Tail Type *B*	8	0	1	0
Tail Type *C*	7	6	3	1
Tail Type *D*	3	0	2	0
Sparkling Tail	10	2	1	5
Dark Fragments	1	1	0	7
Dark Smoke following	1	7	3	1

According to Table V, the colors of the nuclei give hardly any guidance, as they exhibit a wide disparity within each group. Perhaps to some extent the distances of the observers and the different angles of illumination by the sun, and the lack of experience of the observers, are responsible for these color differences. The other characteristics are somewhat more pronounced for the different groups. It is remarkable that of the 12 known examples of the curious type *B* of tail, 8 converge within the circle of *P* (and 3 are unknown as to the direction). 9 of them were said to have a yellow or red nucleus and 3 a white or bluewhite nucleus; the latter color is, perhaps, an effect of the distance, as all these 3 observations were made in western Scania. Unfortunately, none of the observations relating to this type of tail has a checked time, nor is anyone of them associated with an explosion. Thus it may very well happen that 2 different fireballs have been taken together provisionally as *P*. In fact, the 4 directions measured by compass, of type *B* fireballs, converge with one another some 30 km. nearer to Bornholm than the point *P*.

Group *Z* seems to be characterized by a dark smoke appearing immediately after the explosion, group *Q* by tails of type *A*, and group *R*, as mentioned previously, by dark fragments ejected at the explosion. Perhaps these different features may help us to identify and to separate different fireballs, but it should be understood that these identifications are still preliminary and also very difficult to make. A closer selection may be necessary later. We do not know as yet, whether any of these fireballs can be sufficiently distinguished from the others and furnished with sufficiently numerous accurate directions so as to allow a determination of the orbit and the velocity. Perhaps it will be possible only to

take together all directions of the *P*, *Z*, and *Q* groups and try to derive an orbit and a mean velocity common to the 3 groups. In both cases a main difficulty arises from the fact that very few, or even none, of the observers seemed to be situated south of the track. Thus it may be difficult to derive the plane of the orbit. I shall return to this question in an exhaustive publication of the present material to be published later.

Except for the previously mentioned points of convergence, *i.e.*, *P*, *Z*, *Q*, *R*, *V*, *X*, and *Y*, there are several others, in the single cases being more or less doubtful. Thus there is some indication of a convergence point *O* in western Scania, east of Malmö and south of Lund, but its reality is rather doubtful. From this very part of the country there happen to be also 3 reports of fireballs observed as apparently near the ground and in front of certain hills or forests. There is only one similar report elsewhere, although, of course, possibly hundreds of observers thought that the fireball was only some few hundreds or thousands of meters away from them. No meteorite, however, has been located as yet. Other doubtful convergence points are indicated S.E. and E. of Öland and are provisionally denoted by *T*, *U*, and *W*. Considering *P*, *Q*, *R*, *V*, *X*, *Y*, and *Z* as rather well indicated, remembering the fireball observed at the checked time $18^h\ 23^m$, taking the 2 observations between $18^h\ 00^m$ and $18^h\ 14^m$ to represent at least one fireball, considering *O*, *T*, *U*, and *W* to represent at least two fireballs, and finally including one fireball seen in the E.N.E. very far in the N., namely in the landscape Närke at the 59° parallel, we obtain a minimum number of 12 different fireballs observed on this evening. But the material indicates indeed many more fireballs in the interval 18^h-20^h on May 27. There is a slight indication that the fireballs fell more in the N.E. with increasing time; *e.g.*, 3 observations shortly after 20^h indicate that the convergence point *Y* was N.E. of Gotland.

TABLE VI

FIREBALLS OBSERVED ON DAYS PRECEDING AND FOLLOWING MAY 27

Place	Date	G.M.T. h m	Character	Remarks
Hamburg, Germany	24/5	21 45	"Sternkugel"	Motion from N. to S.
Västerås Sweden	26/5	0 05	Bright Meteor	From W. somewhat to S.
Degerhamn, Öland, Sweden	26/5	2 00	Fireball	Seen in W., motion from N. to S.; exploded in small fragments.
Connecticut, U. S. A.	26/5	6 25	Fireball	From W. to N. Published in *The Sky*, August, 1938.
Southern Belgium	26/5	23 40	Fireball	From S.W. to N.E. Reported by Professor Delporte.
Trollhättan, Sweden	28/5	22 00	Fireball	From N.W. to N. Very slow motion.
Marieholm, Sweden	28/5	24 00	Bright Meteor	In N.E. Tail from the zenith to the horizon.

It is somewhat curious that 546 observers noted the phenomenon in Sweden and Denmark, but only 2 in Germany (both saw it in the northern sky), and, as far as I am aware, none at all in the other countries surrounding the Baltic, *e.g.*, Poland, the Baltic States, and Finland. Perhaps the sun, in the N.W., was responsible for this fact, as well as for the further fact that no one saw fireballs in the N.W. But there are at hand 7 reports of fireballs or bright meteors observed on the days immediately preceding and following May 27. Table VI summarizes these reports. Whether the fireballs in question may be related to the meteoric stream of the evening of May 27, or were brought to light simply because of the newspaper request, is of course an open question. The latter alternative would, however, indicate a rather high ordinary fireball frequency.

As is well known, fireballs appearing in large numbers, simultaneously or almost simultaneously, constitute an exceptional phenomenon, but one not quite unique. In the *Journal of the Royal Astronomical Society of Canada* for May-June, 1913, Dr. *C. A. Chant* published an exhaustive description of a train of fireballs seen from Canada, the U.S.A., and the Bermuda Islands on the evening of February 9, 1913.[1] Some 150 reports, in addition, are quoted. The Canadian display has many similarities but also large dissimilarities to the phenomenon of May 27, 1938, studied here. It occurred shortly after 21^h local time, in the darkness, and consisted of a long train of apparently horizontal and surprisingly slow meteors, both large and small. Several or many of these meteors were seen simultaneously by the same observers, and the whole display lasted for about $3^m.3$. The colors were fiery red or golden yellow, and the meteors were followed by tails, mainly of type *A*, some of them sparkling. The meteors appeared in groups, and in many cases a thundering noise was heard.

It is to be hoped that we have not to wait another 25 years in order to see again a meteoric phenomenon similar to those mentioned previously. Discoveries of novae, formerly exceptional, but nowadays rather frequent, teach us, perhaps, that "unusual phenomena" are not so "unusual" as was at first thought.

My thanks are due to Dr. K. Lundmark, who gladly equipped several small expeditions from the Observatory at Lund which made it possible to check up the observations to the extent described in this paper. The splendid coöperation of the Swedish amateurs is made clear, perhaps, in the foregoing account, but it is an agreeable duty to me to express here the sincere thanks of Dr. Lundmark and myself, to all the observers who have communicated their results to the Observatory at Lund.

Observatory, Lund, Sweden, December, 1938.

[1] *Cf.* also *M. Davidson* in the *Jour. Brit. Astr. Assoc.*, **24**, 101, 1913-14. In the same volume are reported also two somewhat similar, although lesser, displays of earlier dates, *viz.*, 1866 (p. 223) and 1876 (p. 168).

The Light Curves of Novae

By DEAN B. McLAUGHLIN

(Continued from page 494.)

Data from Light Curves

Plots of the original observations of novae were studied and compared rather extensively by the writer. As a result, reconstructions were made of some of the incomplete curves, though others were so fragmentary that there was not sufficient evidence for restoration of the missing parts. It is believed that these reconstructions are conservative. Each case was a law unto itself; no *fixed* standard curve was used. Rather, each curve was so restored as to conform to the established characteristics of the better-known curves. The lengths of the gap or gaps in the observations, coupled with internal evidence furnished by the observations themselves, were the chief guides.

One of the chief points to be restored is the apparent magnitude at maximum when that phase was missed. Other characteristics of the curves are intimately bound up with it. As an illustration, we may take Nova Sagittarii 1898. It was found bright, magnitude 4.9, on the first plate taken that year, and its decline was moderately rapid. But at magnitude 8.4 there was a pause, with a slight tendency to brighten; then the observations ceased for five months. The question arises: was the pause the beginning or the end of the transition? If the beginning, we may take the magnitude of maximum as 4.5; if the end, it must have been about 2.5. Decision was made in favor of the fainter magnitude, because the choice of the brighter would make the total range 14 magnitudes, a rather extreme value, though it is closely approached by a few stars.

After restoration of the curves, the time intervals required for the decline through two, three, and seven magnitudes were read off. In each case the time was measured from maximum to the *last date* on which the nova was of the brightness concerned. Thus, the time taken by Nova Herculis to decline seven magnitudes is considered as 1000 days, as if the deep minimum had not occurred, though it passed that brightness on its steep decline only 106 days after maximum. Finally, for those few novae for which the data were available, the time interval from maximum to the end of the decline was estimated.

The durations of the decline through two and three magnitudes were made the basis of classification of the novae as fast, average, or slow. A longer decline was not used because data for seven magnitudes were available in fewer cases, and anything between three and seven magnitudes might be influenced by special behavior during the transition.

TABLE IX

CHARACTERISTICS OF THE LIGHT CURVES OF NOVAE

Nova	Year	Magnitudes: pre-nova	Max. obs.	Max. Extr.	post-nova	Type of Nova	Character of curve: Early Decl.	Trans.	Init. rise da.	Time of decline: 2^M da.	3^M da.	7^M da.	all yr.	Reference
Aqr, VY	1907	<12	8.4	8.0	<16	Fast	smooth			8	13			HB 826
Aql, No. 1	1899	<14.7	6.7	5.5	<15.4	Fast	smooth	dip $1^M.0$		25	33	320	> 3	HA 84
Aql, No. 2	1905	<16.8	8.2	7.6	<15.9	Fast	smooth	smooth	< 9	9	31	230		HA 84
Aql, No. 3	1918	10-11	—1.1	—1.1	10.8	Fast	smooth	osc. $0^M.8$	2	4	8	260	7	HA 81
Aql, DO	1925	<16.5	8.6	8.6		RT	(osc)			300	900			AN 235
Aql, EL	1927	<16	6.4	5.5		Fast	(osc)	osc. $1^M.0$	< 7	(8)	(22)			AN 235
Aql, v356	1936.6	16.0	(7.0)	6.8		Slow	osc!!		2	150				PA 45
Aql, v368	1936.7	<15.0	6.6	5.8		Fast	osc		< 3	25:	50:			PA 45
Ara	1862		5:		<11	?								MN 38
Ara	1910	17.5	6.2	6.0	<15.3	Aver	(osc?)	dip $0^M.5$?	<16	45	75	380		HA 84
Ari, No. 1	1854		9.5		<14.5	RT?								GuL I
Ari, No. 2	1905		12		<15	Fast?				>15				GuL I
Aur, T	1891	<13.7	4.2	3.8	14.8	Slow	osc!!	dip 7^M!!	< 2	80		1800:	15:	HA 84
Boo, Note[1]	1877		4.5:		<10	Slow								AN 155
Car, η	(1843)		—0.8	—0.8		Perm	osc!!			see text				Cape 9
Car, RS	1895	<14.0	7.2	7.0	<15.8	Aver	osc?	osc		30	60	200		HA 84
Cas, B	1572		—5?	—5	?	Aver	smooth	smooth		30	60	200		GuL I
Cen, MT	1931	<14	8.5	8.5	<14	Fast	smooth		< 2	8				BAN 7, 176
Cen, v359	1930	<16	13.8			?								AN 260
Cir, Note[2]	1906	14.9	10.2	?	14.8	Slow	osc			200:	350:		6:[2]	HA 84
Cir, AI	1914	<16.4	10.9	?	<14.5	?								HB 883
Cir, X	1926	<16.7	6.5	6.5		Slow	Note[3]		<23	50:	100:			HB 872
CrB, T	1866	(BD 9.5)	2.0	2.0	10.6[4]	Fast	smooth	dip $2^M.5$		4	6	270	5:	HC 247
Cyg, P	1600		3	3		Perm	oscil			see text				GuL I
Cyg, Q	1876	< 9.5	3.0	3.0	v14.8	Fast	smooth	smooth		5	10	250	8	GuL I
Cyg, No. 3	1920	<15	2.0	2.0	15.5	Fast	smooth	dip $1^M.0$	> 5	7	16	170	> 8	HB 890
Gem, No. 1	1903	<14.4	5.0	4.8	16.5	Fast	smooth	hump	< 4	6	17	150		HA 84
Gem, No. 2	1912	15:	3.5	3.5	14.7	Fast	osc!!	(osc)	1	16	37	550		HA 76
Her, DQ	1934	14-15	1.4	1.4		Slow	osc!!	dip 7^M		67	100	1000:		McL
Lac	1910	14.0	4.6	4.6	14.4	Fast	smooth	smooth	< 4	20	37	300	4	HA 84

TABLE IX—(CONTINUED)

Nova	Year	Magnitudes: pre-nova	Max. obs.	Max. Extr.	post-nova	Type of Nova	Character of curve: Early Decl.	Trans.	Init. rise da.	Time of decline: 2^M da.	3^M da.	7^M da.	all yr.	Reference
Lac, CP	1936	15.3	2.1	2.1		Fast	smooth	smooth	1	5	9	130:		McL
Lyr	1919	<16	6.5	6.5	15.2	Aver	osc		< 2	31	80	650:		HB 705
Mon	1918	15.1	5.6	5.2		Fast	smooth	osc. $0^M.3$	<10	10	21	280		HA 84
Nor	1893	<14.8	7.0	7.0	<16.3	Slow	smooth	dip?	<30	100	180	550	> 5	HA 84
Nor	1920	16.5	9.0	9.0		Slow								HB 734
Oph, No. 1	1604		—3	—3		Aver	smooth	smooth		30:	50:	250:		GuL I
Oph, No. 2	1848		5.0	5.0	v12.6	Slow	osc!			100:	300	5000:	30	GuL I
Oph, BB	1897	<14.2	11.3		<18	Slow?								HB 835
Oph, RS	1933	11.0	4.3	4.3	v11:	F, Rec	smooth	smooth		4	10	95		HB 893
Oph, No. 5	1917	<17	6.5	6.2		F, Pec	osc!!	?	< 7	20	25:			PASP 33
Oph, No. 4	1919	<15	7.4	7.4		Slow	osc!!			120	150			PASP 33
Ori	1667		6?			Rec?								JBAA 4
Ori	1916		11.5		<15	Fast				10:				AN 202
Ori	1939	16:	9.7	9.7		RT			>50					PA 47
Per, V	1887	<14.0	9.4		<16.1	?								HA 84
Per, No. 2	1901	13-14	0.2	0.2	v13:	Fast	smooth	osc. $1^M.3$	1	6	13	300	15	HA 48
Pic, RR	1925	12.7	1.2	1.2		Slow	osc!!	dip $0^M.6$		80	150	1600	>>15	HB 890
Pup	1902	<16	7.0	7.0	<15.0	Slow	osc			120	170	1000:		HB 761
Pyx, T	1920	13.6	6.4	6.4	13.6	S, Rec	osc							HA 84
Sge, No. 1	1783		6:		<15	?								GuL I
Sge, No. 2	1913	<15	7.2	7.2	15.2	Fast	smooth			14	32	300:		HC 219
Sgr, LQ	1897	<15	13.0	(10:)	<16.5	?								HB 859
Sgr, No. 1	1898	<16.0	4.9	4.5	16.5	Fast	smooth	Note[8]		10	20	340	9	HA 84
Sgr, No. 3	1899	14.9	8.5	7.0	14.9	Fast	smooth	dip $0^M.4$?	< 7	(12)	(27)	1000:	4	HA 84
Sgr, HS	1900	16.5	11.5	(10.0)		Slow	osc			>100				HB 851
Sgr, No. 4	1901	<16.1	10.3	(10.0)	<16.1	Slow	osc			>100				HA 84
Sgr, No. 6	1905	<12	7.1	7.1		Fast	smooth?		< 2	16	26			HB 714
Sgr, No. 2	1910	16.4	8.1	7.5		Slow	osc!!	smooth?		220:	320:	1500:	>>10	HA 84
Sgr (Innes)	1912	<17	11	11		RT								U. Cir. 37
Sgr (Innes)	1914	<17	14.2	14.2		RT								U. Cir. 37
Sgr (Innes)	1914	<17	15.8			?								U. Cir. 37
Sgr, No. 7	1914.6	<17	8.0	8.0	<14	Fast	smooth?			<26	<40			HB 733

TABLE IX—(CONCLUDED)

TABLE IX—(Concluded)

Nova	Year	Magnitudes pre-nova	Max. obs.	Max. Extr.	post-nova	Type of Nova	Character of curve Early Decl.	Trans.	Init. rise da.	Time of decline 2M da.	3M da.	7M da.	all yr.	Reference
Sgr, BS	1917.5	<16	9.2	9.2		RT	smooth?			360	750:			HB 788
Sgr, No. 5	1919	14.0	7:		14.0	F, Rec				Note[6]				HB 693
Sgr, GR	1924.4	16.6	11.4	(7.5)	16.5	Fast?	??	smooth		Note[7]			2:	HB 851
Sgr, FL	1924.5	<15	8.3	8.3	<13	Fast	smooth			12	32			HB 847
Sgr, KY	1926	<16	10.6	10.5		Aver	?		<24	<55				HB 861
Sgr, FM	1926	16.5	8.6	8.2	<13	Fast	smooth		<14	22	30			HB 843
Sgr, v363	1927.7	<15.0	8.8	8.8	<16	Aver	smooth	dip?		<42	<70	500:		HB 878
Sgr, v441	1930	16.0	8.7	8.2	15.5	Aver?	osc?			30?	70?	350		HB 890
Sgr, v522	1931	<15.3	12.9	12.9		Fast?				Note[8]				BAN 7
Sgr	1933	<12.5	10.3	9.5		Slow?	osc		<12	70:				AN 264
Sgr	1936.32	<12.7	6.5	6.0		Slow	osc!	dip 3M+	< 2	70:	85:			HB 907
Sgr, v726	1936.37	<16.5	10.8	9.0	<16.5	Fast	smooth		<13	(14)	(34)	150:		HB 907
Sgr, v630	1936.7	15:	4.5	4.5		Fast	smooth			4	9			PA 45
Sco, v384	1893	<15.0	12.3		<15.0	?								HB 902
Sco, v382	1901	<16.5	9.4	9.0	<13	Fast			<12	28:	48:			HB 902
Sco, No. 2	1906	<15.5	9.8	9.8	<15.5	Slow				120:				HA 84
Sco	1922	<15	9.9	9.9		Aver	smooth			45:				HB 775
Sco, KP	1928	<16.5	9.4	9.4		Fast			< 4	22	38			HB 870
Ser, X	1903	14-15	8.9	8.9	<15.4	Slow	smooth	osc?		430	800		> 5	HA 84
Ser, RT	1909	<14.5	10.5	10.5		RT			40:	5y				Gaposchkin
Tau, XX	1927		6.0	6.0	<15.0	Fast	smooth	dip 2M.5	<14	25	44	320		HB 856
Vel	1905	<16.5	10.2	9.8	<14.8	Slow	osc			150:	400:		>>4	HA 84
Vul, 11	1670		3.0		<16.5?	S, Pec				see text				GuL I

Notes

1. Nova Bootis, previously listed as Nova Comae Berenices.
2. Nova Circini: probably the minimum refers to an unresolved companion.
3. X Circini: there is a long gap in the observations; time intervals only rudely approximate.
4. T Coronae: the minimum is certainly the magnitude of an unresolved companion.
5. Nova Sgr, No. 1: interpretation ambiguous; perhaps a dip 0M.5.
6. Nova Sgr, No. 5: decline 5 magnitudes in 150 days.
7. GR Sgr: first observations probably several months post-maximum.
8. v522 Sgr: decline 0.6 magn. in 3 days.

Table IX gives the data from the light curves of all established galactic novae. Of the 85 objects listed, perhaps four or five are subject to a slight element of doubt, but for the most part those objects whose membership in the nova class is uncertain are omitted. The first two columns give the designation and the year of the discovery observation, which usually coincides with the year of maximum light. For η Carinae, however, the year of maximum is given. The next four columns contain the pre-nova magnitude, the brightest observed magnitude, the extrapolated brightness of maximum from the reconstructed curves, and the post-nova brightness. In the seventh column each nova is designated as fast, average (Aver), slow, RT Serpentis type (RT), or permanent (Perm). Recurrent novae are designated as fast (F, Rec) or slow (S, Rec) on the basis of rate of decline, and two objects are indicated as peculiar (Pec). The eighth column indicates the character of the early decline as smooth or oscillatory; the ninth describes the transition as smooth, oscillatory (with the range of fluctuation), or as a dip, with the depth of the minimum in magnitudes. The upper limit to the duration of the initial rise is given in the tenth column for those cases in which observations were made in the few weeks preceding maximum light. The next four columns give the time intervals of decline from maximum through two, three, and seven magnitudes, and the time required to reach the pre-nova magnitude. The last column contains a reference to the source of the data. This cannot be complete; usually the reference of latest date is given.

Statistics of Magnitudes

It would mean very little to discuss the distribution of apparent magnitudes without a certain selection for reasons of homogeneity. In Table X the distribution of the extrapolated maxima is shown for novae since 1890 for which reconstruction of the curves was possible.

For the stars in general, the ratio of increase of the total number, even of faint magnitudes, is greater than 2.0, hence it is evident that many novae are undiscovered. If we assume, for purposes of demonstration, that our list is complete to magnitude 4.0, and that the ratio of increase is actually 2.5 (the same as that for magnitude 12 to 13 for all stars), then we should have about 800 novae brighter than magnitude 9.0 in the

TABLE X

Apparent Magnitudes of Novae at Maximum

Mag. group	Number of stars	Total to limit	Ratio of increase
brt. to 2.0	5	5	
2.1 to 3.0	1	6	
3.1 to 4.0	2	8	1.3
4.1 to 5.0	5	13	1.6
5.1 to 6.0	7	20	1.5
6.1 to 7.0	10	30	1.5
7.1 to 8.0	8	38	1.3
8.1 to 9.0	10	48	1.3
9.1 to 10.0	7	55	1.1+

past 48 years, or about 16 per year. This is comparable, as to order of magnitude, with Bailey's estimate of 25 per year.*

The distribution of apparent magnitudes at minimum is shown in Table XI.

TABLE XI

APPARENT MAGNITUDES OF NOVAE AT MINIMUM

Magnitude group observed minima	Number of stars	Invisible min. fainter than	Number of stars
10.1 to 11.0	2		
11.1 to 12.0	1		
12.1 to 13.0	2		
13.1 to 14.0	3		
14.1 to 15.0	8	14.0	3
15.1 to 16.0	9	15.0	13
16.1 to 17.0	7	16.0	19
17.1 to 18.0	1	17.0	6
	33		41

Eleven objects are omitted from Table XI because the data are incomplete for various reasons.

Ranges of magnitude from minimum to the extrapolated maximum are tabulated in Table XII. Three of the stars with observed minimum are necessarily omitted because of the great uncertainty of the magnitude at maximum.

TABLE XII

RANGES OF MAGNITUDE OF NOVAE

Interval of range	Number of Stars
< 5.5	1*
5.5- 6.4	2
6.5- 7.4	4
7.5- 8.4	6
8.5- 9.4	2
9.5-10.4	2
10.5-11.4	3
11.5-12.4	6
12.5-13.4	3
$\geqslant 13.5$	1†

*Nova Circini 1906. †Nova Cygni 1920.

The two maxima of frequency at eight and twelve magnitudes are a distinct surprise. The group of smaller range contains the three repeating novae and a few more slow novae than the group of larger range, but it would be rash to conclude that there is any real physical difference between the two groups. It appears wisest to withhold judgment because of the small number of individuals concerned.

However, to illustrate the possibilities, let us consider an explanation in terms of discovery effect and the "luminosity function." Let us assume that the true frequency of ranges follows a skew distribution, with the number dropping off rapidly with greater range. Let us assume further that all novae, regardless of range, are of the same average absolute

*POPULAR ASTRONOMY, **29**, 554, 1921.

luminosity at minimum. Then it follows that those of greater range, though fewer in a given volume of space, will be of higher luminosity, and will therefore stand a better chance of discovery. Thus, the maximum at eight magnitudes might express the greater frequency of novae having the smaller ranges, while that at twelve magnitudes was due to the rapid increase of chance of discovery. The minimum between would then be due to the actual smaller number of novae of larger range, and the relatively low probability of discovery of all but the brightest. The writer does not subscribe to this hypothesis; it is introduced as a warning against assuming that the two maxima represent a real characteristic of the novae.

The Average Range of Magnitude

The attempt to determine the average range is beset with difficulties. Even when we have observations at minimum, several factors conspire to reduce the calculated average range. (1) Since the stars of largest range may have minima beyond the limit of the photographs, we may actually be giving preference to those of less than average range. (2) For many photographically discovered novae the maxima were missed, and conservative reconstruction of the curves is likely to reduce the range. (3) On plates of small scale a faint star close to the nova and brighter than its minimum may be mistaken for it. (4) If we use observed minima in the post-nova stage, we may actually be using magnitudes a little too bright, if the return to minimum was slow.

In computing average ranges, the supposed supernovae of 1572 and 1604, and the RT Serpentis stars, were omitted. Computations were made in several ways: using observed ranges and lower limits of range, and including and excluding the three repeating novae and Nova Circini 1906. When plate limits were used, limiting ranges less than 7.0 magnitudes were excluded. It is believed that the resulting tendency to raise the average is more than counteracted by cases in which the minimum is several magnitudes fainter than the plate limit. This appears to be confirmed by the larger ranges calculated from observed maxima and minima. For stars conspicuously variable at minimum the average magnitude at minimum was used. The results are given in Table XIII.

TABLE XIII

Average Range of Novae

	With N Cir and 3 repeaters		Without N Cir and 3 repeaters	
Data used	Av. range Mags.	No. of stars	Av. range Mags.	No. of stars
A. Observed brightest and observed min.	9.8	27	10.3	23
B. Obs. & extrap. max. and obs. min.	9.9+	27	10.5	23
C. Same as A, plus plate limits	>9.5	40	> 9.8	36
D. Same as B, plus plate limits	>9.7	40	>10.0	36

Allowing for the several causes which tend to decrease the calculated range, we conclude that the typical average range of a nova is quite

surely 11 magnitudes, with some possibility of 12 magnitudes as an extreme value.

The question arises whether there is any difference of range between slow and fast novae. The most reliable data give the following results.

Data used	Fast Novae Av. range Mags.	Fast Novae No. of stars	Slow Novae Av. range Mags.	Slow Novae No. of stars
Observed brightest and obs. min.	10.6	15	9.6	7
Obs. and extrap. max. and obs. min.	10.8	15	9.8	7

Considering the small number of individuals, the result can hardly be called conclusive. Although the impression persists that the slow novae have smaller average range, we note that the three best known examples of slow novae, T Aurigae, RR Pictoris, and DQ Herculis, have ranges of 11.0, 11.5, and 13.4 magnitudes respectively,—all in excess of the calculated average range of 15 fast novae.

Rates of Decline

The times of decline which are tabulated in Table IX show a practically continuous distribution from the shortest to the longest. When they are grouped in equal intervals of $\log t$, with $\Delta \log t = 0.1$, we obtain the frequency diagrams in Figure 6.

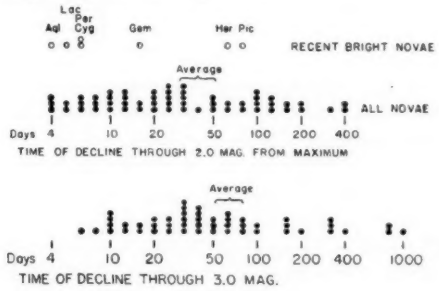


Figure 6

Frequency Diagrams for Times of Decline of Novae through Two and Three Magnitudes.

Note that several recent bright novae are bunched on the rapid side of the frequency distribution.

The maximum of frequency for the decline through two magnitudes occurs near the middle of the range, and there is a general tapering off in both directions. But a minimum occurs just on the long-time side of the maximum, and it would be easy to point this out as the division between slow and fast novae. Indeed, those which are designated as average do fall right in the region of this minimum. However, this has no physical significance; a slight *allowable* modification of a few of the curves would go far towards filling the gap.

The frequency diagram for times of decline through three magnitudes

confirms the belief that the minimum is not significant. If we identify the average novae in this plot, we find seven of them present, and there is no trace of a minimum at their position. There is therefore no justification for assuming a real division between slow and fast novae.

The membership of the slow and fast groups would be altered somewhat if we used seven magnitudes decline, instead of two or three, as a criterion. The changes, however, would occur in the neighborhood of the interval corresponding to the average; in the main, the decidedly fast and slow novae would still be separated in the same way.

Data on the decline to pre-nova magnitude are relatively scanty, and we can only state that, while the very slow and very fast novae are still differentiated, there are indications of some overlapping of the time intervals (*Cf.* the earlier discussion in the section on "The Final Decline").

The general result of the classification of the 85 novae which are listed in Table IX is as follows:

Fast novae	35
Average	9
Slow novae	23
RT Serpentis type	7
"Permanent"	2
Unknown	9
Total	85

We are thus justified in stating that slow novae are quite common, and that the idea that the very fast novae are the truly "typical" objects is erroneous.

The plot of the times of decline of the seven bright novae of the twentieth century (see Figure 6) shows how this error has come about. Astronomers have been most strongly impressed by the behavior of these brightest objects. Now it is noticeable that these seven are quite unsymmetrically distributed with respect to the frequency diagram. Prior to 1925, three of the four bright novae fell at the extreme fast end of the distribution, and the fourth, Nova Geminorum 1912, was decidedly on the rapid side of the average. It has taken two bright slow novae to impress the truth upon nova specialists. But the erroneous view has such a wide circulation in the literature of general astronomy that we may expect some years to pass before it can be stamped out.

Further Desirable Investigations

In the course of this work it became apparent that there is a large amount of work which can be done on magnitudes of novae, with the use of photographs already existing, and that a relatively small amount of new supplementary material would improve our knowledge appreciably. The following investigations are suggested.

(1). Existing photographs probably contain images of several novae which were not recorded on any plates available at the time of discovery.

These could be supplemented by a few long exposures to reach fainter stars. This would doubtless add a number of determinations of minimum brightness and so improve our knowledge of the ranges of variation.

(2). Existing material probably contains the record of the complete declines to minimum of several novae for which the published observations are incomplete because they included only data for a year or two after maximum. The recent novae should be followed closely enough in the future to determine good curves all the way to minimum.

(3). A number of novae are bright enough at minimum to be recorded on a large number of photographs. Examination of those plates would furnish more information about the prevalence of variability after minimum is reached. A series of plates of sufficiently long exposure to record the variations of fainter novae would also pay large dividends in the form of results on numerous other variables in the same fields.

(4). For several moderately bright novae the detailed observations have never been published. Thus, the light curves of Nova Puppis 1902, Nova Lyrae 1919, and Nova Ophiuchi 1919, are known only from general descriptions or, for the last named, from a published curve which contains a serious error. In the present state of our knowledge of novae there can be no such thing as too many observations.

Summary and Conclusion

The preceding paper has been purposely limited to the behavior of novae as manifested by their light variations alone. It has been necessary to omit entirely any description of the complex spectroscopic phenomena which accompany the light changes. The inclusion of even a small portion of the spectroscopic material would have lengthened the paper beyond reason.

With the frank admission that any analysis of nova behavior will tell less than half the story if spectrum variations are excluded, we now proceed to summarize the conclusions of this paper. This will involve some repetition of data given in greater detail in the various tables earlier in the paper, to which reference should be made. It is also too much to expect that we can describe the variations completely in terms of the characteristics of only two or three classes of objects, without noticing important exceptional cases. Within these limitations, however, we may summarize the "light life" of typical novae of the fast and slow classes somewhat as follows.

In the pre-nova state, the great majority of these stars are fainter than the fourteenth magnitude. Relatively scanty data show that perhaps half of them vary irregularly through a magnitude or so before the outburst. The initial increase, nine magnitudes in the average case, takes place in two days or so, regardless of the later rapid or slow behavior of individual stars. The fast and slow novae are differentiated at the pre-

maximum halt whose duration ranges from zero for the most rapid to many days for the slowest novae. The final rise through two magnitudes to maximum then occupies from a day to a few weeks, and after a brief stay at maximum (a few hours to several days) the star begins to fade.

The decline from maximum may be smooth or irregular; in general the tendency towards irregularity increases with increasing slowness. When the light has faded through 3.5 magnitudes, the "transition" begins. In this stage the nova may exhibit strong fluctuations of light, a deep minimum with subsequent recovery, or a quick decrease of the rate of decline. The transition is at an end when the light has faded to about six magnitudes below maximum, and by that time the spectrum is in the nebular stage. From there on the decline is uneventful, with only slight irregularities. After several years the star reaches a luminosity nearly or quite equal to that of the pre-nova stage. Small fluctuations of light may continue for a number of years.

The rates of decline show a broad and practically continuous distribution with little bunching. The rate of "average" novae is two magnitudes in about 40 days, or three magnitudes in 70 days. Classification of novae according to rates of decline shows that slow novae are quite numerous, and that there is no true demarcation between fast and slow novae. The error of the belief that the fast decline represents the truly typical case is pointed out, and it is traced to the accident of the extreme rapidity of a few of the brightest novae, whose behavior seems to have impressed astronomers most strongly.

Although more than eighty galactic novae have been recorded, there is still an urgent need for more nearly accurate light curves of more of these objects, and it is important that recent and future novae be followed closely throughout the course of their variations.

The Observatory, University of Michigan, June, 1939.

Note added November 3

Since the above paper was written, another authentic recurrent nova has been added to the list. The star U Scorpii, which Pogson observed fading rapidly for only eight days in 1863, was regarded as doubtful and was not even included in Table IX. *Harvard Announcement Card* 508 records observations of two more maxima of light about equal to the first (magnitude 8.8) in 1906 and 1936. The rate of fading in both 1863 and 1936 was at least equal to the most rapid recorded for any nova. At minimum the star is fainter than $17^{M}.6$.

The well-known "nova-like" variable Z Andromedae is also recurrent. Principal maxima of earlier outbursts occurred in 1901 and 1915; it is now near the principal maximum of its third recorded outburst (see Popular Astronomy, **47**, 335 and 447, 1939, and *Harvard Circular* **168**, 1911) and its spectrum is of P Cygni type, and hence truly nova-like (Struve, *Publ. A.S.P.*, **51**, 297, 1939). The writer is indebted to Dr. N. T. Bobrovnikoff for taking a spectrogram of the star at his request, prior

to the receipt of Struve's published notice. Z Andromedae should not be regarded as a true recurrent nova; there are features of its light curve which are quite atypical. D. B. McL.

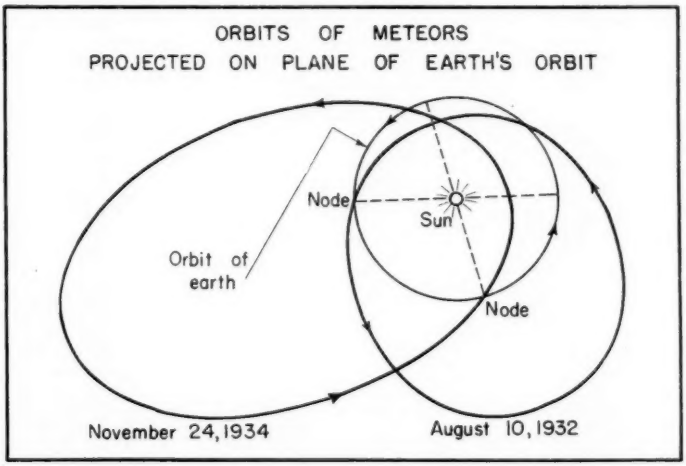
The Calculation of Meteor Orbits

(EXAMPLES)

By C. C. WYLIE

In two earlier papers we have given formulas[1] and tables[2] to simplify the calculation of meteor orbits. In this paper we give the details of calculation of the elements of the orbits for two detonating meteors.

The first meteor selected is that of August 10, 1932, which fell in broad daylight, and dropped meteorites near the village of Archie, Missouri. The data for determination of the path were remarkably complete for a meteor dropping meteorites. The geocentric radiant and the apparent velocity are taken from *Contribution Number 6 of the University of Iowa Observatory*, page 217. The apparent velocity was reduced to the geocentric for the work of this paper.



For this meteor the geocentric radiant was north of the ecliptic, indicating that it fell at the descending node of its orbit. (See "The Calculation of Meteor Orbits, (Formulas)." POPULAR ASTRONOMY, October, 1939).

The second meteor fell with detonations in the morning hours of

[1] "The Calculation of Meteor Orbits (Formulas)," *P. A.*, October, 1939.
[2] "The Calculation of Meteor Orbits (Tables)," *P. A.*, November, 1939.

November 24, 1934. The detonations attracted considerable attention in the cities of Rock Island and Moline in Illinois, and Davenport in Iowa, and were noticed ninety miles from the endpoint of the meteor.

This meteor is of special interest because it fell when the apex of the earth's motion was within a few degrees of the meridian. The geocentric radiant was south of the ecliptic, indicating that the meteor fell at the ascending node of its orbit. The figures for geocentric radiant and velocity are taken from *Contribution Number 6 of the University of Iowa Observatory*, pages 200-201.

EXAMPLES

	Aug. 10, 1932 4:30 P.M.	Nov. 24, 1934 5:50 A.M.
R.A. Radiant $= \alpha_2$	157°39′.4	62° 6′
Decl. Radiant $= \delta_2$	+ 29°14′.8	+ 19°54′
Geoc. Vel. $= u$	8.27 mi.	14.6 mi.
$x = -X$	+ .75346	+ .47080
$y = -Y$	− .62170	+ .79594
$z = -Z$	− .26965	+ .34522
$r = r$	1.01337	.98709
R.A. apex $= \alpha_1$	46° 7′	154° 7′
Decl. apex $= \delta_1$	+ 17°22′	+ 10°43′
cos α_1	+ .69319	− .89968
cos δ_1	+ .95441	+ .98256
V_1	18.26	18.73
sin α_1	+ .72075	+ .43654
sin δ_1	+ .29849	+ .18595
V_{x1}	+ 12.081	− 16.557
V_{y1}	+ 12.561	+ 8.0338
V_{z1}	+ 5.4504	+ 3.4828
cos α_2	− .92492	+ .46793
cos δ_2	+ .87253	+ .94029
$V_2 = u$	8.27 mi.	14.6 mi.
sin α_2	+ .38015	+ .88377
sin δ_2	+ .48857	+ .34038
V_{x2}	+ 6.6741	− 6.4239
V_{y2}	− 2.7431	− 12.133
V_{z2}	− 4.0405	− 4.9695
$V_x = V_{x2} + V_{x1}$	+ 18.755	− 22.981
$V_y = V_{y2} + V_{y1}$	+ 9.8179	− 4.0988
$V_z = V_{z2} + V_{z1}$	+ 1.4099	− 1.4867
tan $\alpha = -V_y/-V_x$	+ .52349	+ .17836
α	207°38′	10° 7′
sin α	− .46378	+ .17558
cos α	− .88595	+ .98446
V' cos δ	+ 21.170	+ 23.344
V' sin δ	− 1.4099	+ 1.4867
tan δ	− .06660	+ .06369
δ	− 3°49′	3°39′
sin δ	− .06645	+ .06356
cos δ	+ .99779	+ .99798
V'	21.217	23.391
f	5.4067×10^{-2}	5.4067×10^{-2}
$G = fV$	1.1471	1.2647
$x' = fV_x$	+ 1.0140	− 1.2425
$y' = fV_y$	+ .53083	− .22164
$z' = fV_z$	+ .07620	− .08040

EXAMPLES

	Aug. 10, 1932 4:30 P.M.	Nov. 24, 1934 5:50 A.M.
xx'	+ .76401	− .58497
yy'	− .33002	− .17639
zz'	− .02056	− .02775
rr'	+ .41343	− .78924
r'	+ .40798	− .79943
$2/r$	1.9736	2.0262
G^2	1.3159	1.5995
$1/a$	.65775	.42669
a	1.5203	2.3436
$(r')^2$	.16645	.63909
$G^2-(r')^2$	1.1494	.96038
r^2	1.0269	.97435
p	1.1803	.93575
$\sqrt{p}$	+ 1.0864	.96734
$e\sin v = r'\sqrt{p}$	+ .44325	− .77332
$e\cos v = p/r - 1$	+ .16478	− .05201
$\tan v$	+ 2.6900	+ 14.868
v	69°36′	266° 9′
$\sin v$	+ .93733	− .99774
$\cos v$	+ .34855	− .06710
e	.47289	.77507
$\omega_1 = -v$	− 69°36′	+ 93°51′
$(1-e^2)$	.77638	.39927
a (check)	1.5203	2.3436
rz'	+ .07722	− .07936
zr'	− .11001	− .27598
$rz'-zr'$	+ .18723	+ .19662
$.9174/\sqrt{p}$	+ .84441	+ .94837
yr'	− .25364	− .63630
ry'	+ .53793	− .21878
$yr'-ry'$	− .79157	− .41756
$.3979/\sqrt{p}$	+ .36624	+ .41133
I	+ .15810	+ .18647
II	− .28990	− .17175
$\sin i_1$	− .13180	+ .01472
i_1	− 7°34′	+ 0°51′
a''	3.5141	12.872
P	1.8746	3.5878
Ω_1	318° 2′	61°31′
ω	110°24′	93°51′
Ω	138° 2′	61°31′
i	7°34′	0°51′
xr'	+ .30740	− .37637
rx'	+ 1.0276	− 1.2265
$xr'-rx'$	− .72016	+ .85010
$\sin \Omega_1$	− .66870	+ .87896
$\sqrt{p}\sin \Omega_1$	− .72648	+ .85025
$\cos i_1$	+ .99130	+ .99982
i_1 (check)	− 7°34′	1° 5′

Assembled Elements

a	1.5203	2.3436
e	.4729	.7751
ω	110°24′	93°51′
Ω	138° 2′	61°31′
i	7°34′	0°51′
P	1.8746	3.5878

The elements as calculated show that both orbits are direct, and the eccentricities, inclinations, and periods are less than the average for the short period comets. It is interesting that this holds for the daylight meteor, and even for the meteor which fell when the apex of the earth's motion was almost on the meridian.

The calculations in this paper have been made independently by the author and Mr. J. W. Kitchens, Research Assistant in Astronomy.

UNIVERSITY OF IOWA, JULY 27, 1939

Planet Notes for January, 1940

By R. S. ZUG

NOTE: Greenwich Civil Time is employed unless otherwise stated. To obtain Eastern Standard Time subtract 5 hours, Central Standard Time, 6 hours, etc. The planetary phenomena are described as they are to be seen from latitude 45° N. The data are taken chiefly from the *American Ephemeris and Nautical Almanac.*

Sun. The apparent positions of the sun for January 1 and January 31, respectively, are: $\alpha = 18^h\,41^m.0$, $\delta = -23°\,6'.6$; $\alpha = 20^h\,49^m.6$, $\delta = -17°\,45'.3$. The sun is in the constellation Sagittarius until January 20, when it enters the constellation Capricornus. It will be moving through the latter constellation for the duration of the month. The sun is closest to the earth on January 2, when the earth reaches the perihelion point of its orbit. Values for the equation of time are as follows:

Date 1940	Equation of Time (Mean - Apparent)	Date 1940	Equation of Time (Mean - Apparent)
	m s		m s
Jan. 2	+ 3 26	Jan. 18	+10 4
6	+ 5 18	22	+11 18
10	+ 7 2	26	+12 20
14	+ 8 38	30	+13 9

Moon. Phenomena of the moon will occur as follows:

		h	m
Last Quarter	Jan. 2	4	56
New Moon	9	13	53
First Quarter	17	18	21
Full Moon	24	23	22
Last Quarter	31	14	47
Apogee	Jan. 14	12	
Perigee	26	11	

Mercury. Mercury will be an inconspicuous morning star during January. The planet will reach superior conjunction with the sun, and will become an evening star, on January 31.

Venus. Venus is an evening star of stellar magnitude —3.4. On January 1 the planet sets about 2 hours after the sun. By February 1, however, it will remain above the horizon for three hours after sunset. The planet is moving north, and slowly increasing in brightness and angular diameter.

Mars. Mars is moving eastward through the constellation Pisces during January. On January 4, the planet will be situated on the equinoctial colure, and 15′

south of the vernal equinox. The stellar magnitude of Mars varies from +0.7 on January 1 to +1.1 on February 1. On January 7, Mars will be in conjunction with, and situated 1° 10′ to the north of, the planet Jupiter.

Jupiter. Jupiter is an evening star of stellar magnitude —2, situated a little east of the vernal equinox in Pisces, and is well placed for evening observation.

Saturn. Saturn will be found in the eastern portion of the constellation Pisces during the month of January. It will be in eastern quadrature with the sun on January 16.

Uranus. Uranus is a morning object, nearing western quadrature with the sun. The planet is located near the eastern border of Aries, and will be in the following apparent position, on January 1 and January 31, respectively:

$$\alpha = 3^h\,3^m.6,\ \delta = +16°\,58'.1;\ \alpha = 3^h\,2^m.4,\ \delta = +16°\,54'.1.$$

Neptune. Neptune is now situated in the constellation Virgo, not far from the bright star β Virginis. On January 1 it will be found 2 minutes east of this star and 48′ to the north.

Asteroid Notes

By HUGH S. RICE

Ceres during December is in Leo in a region near bright stars, so that its identification should not prove difficult. Even without a special chart it can be picked up by our directions with the aid of a star chart, late at night. Ceres is found just east of θ Leonis (in the triangle) on December 2. From this place it moves to a position 3° north of β Leonis on January 31. The magnitude averages about 7.5, thus putting it within range of small telescopes. Opposition occurs early in March, 1940.

Pallas comes to opposition in early January, and is therefore observable earlier in the night. However, the declination is much farther south, as it appears amidst the bright stars of Puppis (nearly in conjunction with the star 3(=1) Puppis) on December 2, and goes in a retrograde direction to a point just west of δ Canis Majoris on January 31. The magnitude of Pallas makes it much brighter than Ceres, as it ranges from 7.2 on December 2 to 6.8 at the end of January. It should be easy to locate this asteroid with binoculars or a 2-inch telescope.

Vesta is still observable and, in December, is at its western stationary point at the Cetus-Pisces boundary. This stationary point, reached in the middle of the month is 4½° west and 1° south of α Piscium. Thereafter, in its direct motion, it goes north of this star.

In Taurus, northeast of the Hyades is 532 Herculina, of magnitude 10.1. This asteroid comes to opposition December 9, and is well placed for observation for northern observers. It should be picked up with a 3-inch glass.

Another of the brighter ones among the innumerable asteroids, that are not as well known as the Big Four, is 118 Peitho. This object is also in a good place for northern observers during December and January. Except at the beginning, it will be found in Auriga, between the pentagon of that constellation and the configuration of Gemini. Opposition date is December 26. We give herewith the ephem-

erides of these two asteroids as computed by the Coppernicus Institute at Dahlem, —except that the last position of 532 was done by us by extrapolation.

EPHEMERIDES OF MINOR PLANETS. FOR 0h U.T. EQUINOX 1950.

		532 HERCULINA (10M.1) α h m	δ ° ′			118 PEITHO (9M.8) α h m	δ ° ′
Dec.	3	5 15.0	+ 9 22	Dec.	3	6 40.6	+31 42
	11	5 7.2	+ 9 43		11	6 34.2	+32 38
	19	4 59.3	+10 11		19	6 25.9	+33 28
	27	4 51.9	+10 46		27	6 16.7	+34 7
Jan.	4	4 45.6	+11 27	Jan.	4	6 7.5	+34 32
					12	5 59.4	+34 44

Hayden Planetarium, American Museum of Natural History,
New York City, November 15, 1939

Occultation Predictions

(Taken from the *American Ephemeris*)

Date 1940		Star	Mag.	IMMERSION Greenwich C.T. h m	IMMERSION a m	IMMERSION b m	IMMERSION Angle E from N °	EMERSION Greenwich C.T. h m	EMERSION a m	EMERSION b m	EMERSION Angle E from N °
OCCULTATIONS VISIBLE IN LONGITUDE +72° 30′, LATITUDE +42° 30′.											
Jan.	20	33 B.Tau	6.3	2 54.5	—1.5	+0.2	61	4 5.2	—1.0	—1.9	285
	20	δ Tau	3.9	20 0.8	—0.2	+1.6	80	21 3.3	—0.6	+1.6	255
	20	64 Tau	4.8	20 37.0	—0.9	+0.6	116	21 27.4	—0.3	+2.7	218
	20	68 Tau	4.2	21 41.0	..	..	15	22 13.9	..	..	319
	21	119 H.¹Tau	6.2	2 3.3	—1.9	—0.1	84	3 25.5	—1.7	—0.8	267
	22	119 Tau	4.7	2 26.4	—1.9	—0.3	95	3 47.6	—1.8	—0.6	268
	22	120 Tau	5.5	3 14.8	—1.8	—1.0	105	4 32.1	—1.6	—0.6	261
	23	26 Gem	5.1	7 53.5	—0.6	—1.1	88	8 50.3	0.0	—1.8	295
	26	*h* Leo	5.3	1 41.0	—0.6	+2.4	65	2 28.7	—0.9	—1.0	327
	29	*f* Vir	5.9	9 31.4	—2.4	+0.6	66	10 22.2	—0.8	—2.6	344
	30	*h* Vir	5.4	10 3.5	..	..	49	10 39.0	..	..	357
OCCULTATIONS VISIBLE IN LONGITUDE +91° 0′, LATITUDE +40° 0′.											
Jan.	20	33 B.Tau	6.3	2 18.9	—2.0	+0.8	66	3 43.0	—1.9	—0.9	271
	21	119 H.¹Tau	6.2	1 25.3	—2.0	+0.8	84	2 50.8	—2.1	+0.4	258
	22	119 Tau	4.7	1 50.4	—1.9	+0.4	98	3 11.4	—2.0	+0.7	256
	22	120 Tau	5.5	2 40.3	—2.1	—0.7	114	3 56.7	—2.1	+1.0	244
	23	26 Gem	5.1	7 43.0	—0.9	—1.6	113	8 47.8	—0.8	—1.3	271
	26	*h* Leo	5.3	1 30.7	0.0	+2.0	69	2 17.1	—0.5	—0.4	319
	29	162 B.Vir	6.0	4 16.2	..	..	33	4 27.7	..	..	8
	29	200 B.Vir	6.3	5 54.2	—1.2	+2.8	63	6 34.0	—0.2	—2.0	346
	29	*f* Vir	5.9	8 50.4	—1.8	+0.2	102	10 5.5	—1.5	—1.2	313
	30	*h* Vir	5.4	9 15.1	—1.9	+0.8	90	10 25.8	—1.3	—1.2	320
OCCULTATIONS VISIBLE IN LONGITUDE +120° 0′, LATITUDE +36° 0′.											
Jan.	20	33 B.Tau	6.3	1 21.9	—1.2	+2.4	50	2 39.7	—2.2	+0.2	274
	21	119 H.¹Tau	6.2	0 40.7	—0.7	+1.9	66	1 51.9	—1.4	+1.0	268
	22	119 Tau	4.7	1 9.3	—0.7	+1.4	84	2 17.9	—1.1	+1.2	261
	22	120 Tau	5.5	1 49.4	—1.3	+0.6	104	2 57.6	—1.2	+1.9	242
	23	26 Gem	5.1	7 7.2	..	..	162	7 46.4	..	..	218
	29	*f* Vir	5.9	8 19.7	—0.5	—1.1	149	9 16.7	—1.6	+1.3	261
	30	*h* Vir	5.4	8 44.0	—0.4	—0.4	137	9 45.1	—1.2	+1.0	270

The quantities in the columns *a* and *b* are given for the purpose of making these predictions useful for any place within 200 miles of the point indicated. The procedure is as follows: Subtract the longitude of the point given from the longitude of the place in question; multiply the result in degrees, taking the signs into account, by the quantity under *a* for the star to be observed; similarly, with the latitude, using *b*; apply the sum of the products, with its proper sign, to the Greenwich C.T., and obtain the predicted Greenwich Civil Time for the phenomenon at the place of observation. To obtain Eastern Standard Time it is necessary to subtract five hours; Central Standard Time, six hours, etc.

Comet Notes

By G. VAN BIESBROECK

Two more comets have been added to the already long list of those found this year.

Comet 1939 *m* (Periodic Faye). One of them is the expected periodic comet Faye which was first photographed by J. M. Jeffers at the Lick Observatory on November 3. He gave the following data:

1939 November 3 at $4^h\ 0^m1$

Right ascension, $20^h\ 13^m\ 28^s3$ Declination, $-10°\ 18'\ 15''$

Diffuse coma of magnitude 16

This indicates that the prediction by the English computers, W. P. Henderson and P. J. Harris (*Handbook of the British Astron. Assoc.* 1939), is very accurate and that a small change of a quarter of a day later in the date of perihelion will represent the measures. The recovery was made almost six months before perihelion (1939 April 23) so that the object will be well followed. But it will remain very faint until next spring. This is the tenth return of this periodic comet since it was first found in 1843.

Comet 1939 *n* (Friend). The other comet found this month is a new one. It was discovered by Clarence L. Friend, amateur astronomer living at Escondido, California. In the evening of November 1 he noticed the comet as a faint round coma in the position $16^h\ 31^m$, $+35°$. The discovery was not announced immediately so that observers were not informed until November 5. Since then the object has been followed in many observatories. The first announcement gave the magnitude as 12. I found the object easily visible in a small telescope and estimated the total brightness as equivalent to that of a 9^M star; this was obtained by comparing extra-focal images of stars and the comet so as to make them more similar. With the 40-inch telescope on November 9, I noticed that in the center of the diffuse coma, which extended to a diameter of 4′, there was a sharp nucleus of about 13^M.

Already preliminary computations have been made of the orbit. The following two sets of elements are at hand at the moment of writing:

	Berkeley	Ann Arbor
Perihelion	1939 Nov. 6.149	Nov. 6.5768
Perihelion to node	128° 31′	130° 39′ 12″
Longitude of node	198 11	200 55 54
Inclination	92 7	90 53 18
Perihelion distance	0.9377	0.92630

The first set was determined by students at the astronomical department of the University of California, the second by A. D. Maxwell and H. R. J. Grosch. Both depend on three successive nights of observation and will, of course, require further sharpening up but the general character of the orbit is sufficiently defined. The comet moves in a plane almost perpendicular to that of the earth's orbit. It was found when near its minimum distance from the sun and near maximum brightness. The following ephemeris, based on the Ann Arbor orbit, shows that the object moves rapidly southward through Hercules and Aquila:

	h	m	°	′
Nov. 13	18	10	+27	0
17		50	21	40
21	19	29	15	30
25	20	4	9	2
29	20	35	+ 2	33

At the same time the brightness will rapidly decrease on account of the increasing distances.

These two recent discoveries bring up to twelve the number of comets found in 1939 and to seven the number visible simultaneously in the beginning of November! This is a very unusual frequency but, of course, most of these objects can only be seen with large telescopes. In the evening sky aside from the easily observable comet Friend there are periodic comets Giacobini and Faye, both very faint and the first one difficult on account of low altitude. Later in the night we have periodic comet Kopff now as faint as 17^{M} and periodic comet Brooks of magnitude 14. In the morning sky periodic comet Tuttle is now at its brightest, having reached $8^{M}.5$ on November 11. It appears as a well condensed round coma but does not show any tail. However, before the month is over it will have disappeared below the southern horizon. Finally in the northeast morning sky the presence of comet Rigollet can still be verified. Its diffuse coma has now faded to magnitude 15, yet a short tail pointing southwest still shows clearly.

Except for comets Faye and Friend all these comets will probably be too faint for further observations in December.

Williams Bay, Wisconsin, November 11, 1939

METEORS AND METEORITES

Meteor Notes from the American Meteor Society

By CHARLES P. OLIVIER, President

The month of October, 1939, was looked forward to with eagerness by meteor observers because there was hope that the Draconid meteors, connected with the Giacobini-Zinner Comet, would return in a fair, if not excellent, shower. This shower, so far as reports to the A.M.S. are concerned, simply did not appear. Many in America, including members of the staff of Flower Observatory and a group in Hawaii, were on the lookout. The results were wretchedly poor. So far as I personally was concerned I did not see a single meteor in a series of short watches in the early hours of darkness on October 9 and 10. However, I did not undertake regular observations, only holding myself ready if there were need. Others who kept regular watch had poor luck. As partial exceptions we mention Vernon Avery, Banks, North Dakota, who on October 9-10 found a rate of 11 per

hour with one probable Draconid; and P. N. Klass of Dubuque, Iowa, who on October 10-11 found a rate of 24. It will take considerable study of his maps to determine the class of the meteors, as possible Draconids are very far from the radiant. A group in Hawaii, under Miss Larrabee, counted on October 9-10. These counts need some analysis, but the averages were low. All this means that, unless the shower returned for a very few hours and was visible only in some remote part of the world, central Asia for instance, the earth missed the stream in 1939—or there were no meteors to meet in this part of the comet's orbit.

The Orionids were more considerate and gave us at least a moderate display. Plans were made and carried out for simultaneous observations on the nights of October 19-20 and 20-21 at Baltimore and at Flower Observatory. Paul S. Watson, assisted by P. G. Crout, observed at the former. C. P. Olivier and S. G. Barton observed each one night at the latter. Observations continued from 12 to 15 hours and the sky conditions were fairly good for city stations. A superficial examination of the records gives from 15 to 20 meteors observed simultaneously from both stations. Later computations will be undertaken on these objects. The hourly rates at Baltimore were 7.0 and 9.3; at Flower Observatory, 10.0 and 5.3. On October 21-22 George Wetherill, one of our younger members who lives very near Flower Observatory, observed from 16:10 to 17:25, $F = 0.8$, and plotted 28 meteors. Also Leon Arslonian, San Jose, California, on October 20-21 had a rate of 49 per hour from a count between 13:00 and 14:45, $F = 1.0$. These bear out that the maximum of the Orionids now falls later than October 19-20, which about 1900 was certainly the date.

W. R. Stone of Santa Barbara, California, who I believe holds the all-time record as an active meteor observer (he writes that he was 87 this fall) worked for several hours each on four consecutive nights, beginning October 17-18, but this year seems not to have had very good fortune in the numbers seen. We have also a good report from Campbell McArthur, N. Quincy, Massachusetts, for October 16-17, 18-19, and 20-21 (maximum on last date with a rate of 24); and from George E. Lambert of Bronx, New York, who observed on 6 nights during the Orionid epoch. Both of these observers plotted all meteors. Joseph Leerman, Baltimore, Maryland, made counts on 3 nights, maximum on October 19-20, rate 16. Tabular data for all these observers will be published when radiants, etc., are worked up; this is only a preliminary statement. We expect other belated reports to arrive.

I wish to mention the recent receipt of observations from Stetson University, Deland, Florida, sent in by J. Francis Knorr of the Department of Astronomy. They refer to simultaneous work done at two stations by groups of faculty and students with a view to height determinations. The Leonids and Geminids of 1938 and the Lyrids and Orionids of 1939 are included. There are over 900 observations, and a large number of good heights should come from them. I greatly regret that I do not have a special computer to whom I could at once turn over this fine series. As it is, there will be some inevitable delay in working out the heights.

Attention should be called to several important papers on meteoric astronomy which have appeared within a year in "Proceedings of the American Philosophical Society." These include papers by Fred L. Whipple and Fletcher Watson of Harvard College Observatory, and by J. D. Williams of Princeton University Observatory. They are found in Vol. 79, Part 4, and in Vol. 81, Part 4. Members of the A.M.S. would do well to study these papers. They may be obtained by addressing the above Society at Independence Square, Philadelphia, Pennsylvania.

Vol. 81, Part 4, contains five meteor articles and costs 50 cents. The other has only one meteor article and is more expensive though valuable to those specially interested in photography of meteors.

May I mention that the annual dues for the A.M.S. should be paid in January. It would save trouble, time and expense here—all quite needless—if our members would remit without forcing us to send out bills. It is hoped that a new membership list will appear some time in 1940.

Flower Observatory, Upper Darby, Pennsylvania, 1939 November 7.

Contributions of the Society for Research on Meteorites

Edited by FREDERICK C. LEONARD,
Department of Astronomy, University of California, Los Angeles

President of the Society: H. H. NININGER, Colorado Museum of Natural History and American Meteorite Laboratory, Denver

Secretary of the Society: ROBERT W. WEBB, Department of Geology, University of California, Los Angeles

The Metallurgical Interpretation of the Structures found in Meteoritic Irons*

By GERHARD DERGE,
Metals Research Laboratory, Carnegie Institute of Technology, Pittsburgh, Pennsylvania

ABSTRACT

Two crystallographic mechanisms have been established for the transformation from the high-temperature, face-centered cubic lattice of γ-iron to the low-temperature, body-centered cubic lattice of α-iron. Published researches on meteorites were not adequate to establish which of these two mechanisms operated in the formation of the coarse Widmanstätten patterns found in meteorites. It was felt that a study of these patterns in meteoritic irons would contribute to the understanding of these mechanisms.

An investigation of the macro- and micro-crystalline perfection of an Amalia Farm [= Bethany, Great Namaqualand], South Africa, and a Canyon Diablo, Arizona, meteorite established that the latter was far better suited for an X-ray study of the orientation relationships in the structure. In the course of the research it was established that one of the mechanisms operated at high transformation temperatures, while the other operated at much lower temperatures. The orientations in the Canyon Diablo sample corresponded to those predicted by the high-temperature mechanism. This, and other metallurgical evidence, is in accord with the theory that the Widmanstätten patterns in meteorites are formed by extremely slow cooling from high temperatures.

Recent advances in physical metallurgy have developed very useful correlations between rates of solid reactions and the resultant structures (coarseness of pattern) and between speed and temperature of plastic deformation and the type of deformation which occurs (slip, twinning, and cleavage). The application of this knowledge, in conjunction with adequate experiments on alloys of meteoritic

*Read at the Sixth Annual Meeting, Richmond, Virginia, December, 1938.

composition, would undoubtedly lead to definite knowledge concerning the origin and the history of meteorites.

A review of the metallurgical literature dealing with meteoritic structures produces a list of names which parallels very closely a list one might make of the outstanding leaders in the development of our present science of physical metallurgy. It includes such names as Faraday,[1] Widmanstätten, Roozeboom, Sorby, Osmond, Benedicks, Tammann, Belaiew, and Guertler.[2] The pronounced crystallographic patterns produced by polishing and etching a meteoritic iron convinced these workers that all metals are crystalline and that the properties of these crystalline structures must form the basis of their scientific study. The close similarity

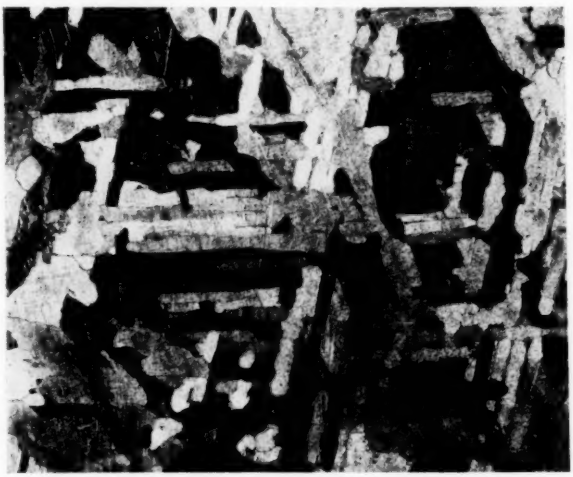


FIGURE 1

THE WIDMANSTÄTTEN PATTERN OF A CANYON DIABLO, ARIZONA, METEORITE. Magnification, ×1.

of the coarse Widmanstätten patterns, visible with the naked eye in meteorites, to the finer figures which may be observed in properly treated steels by the use of the microscope, was recognized by these early workers, but it remained for a modern American metallurgist, R. F. Mehl,[3] to point out the full significance of these structures as typical of all solid-metal reactions. The series of researches which have followed in his own and other laboratories have produced a vast amount of information concerning these reactions. It is the purpose of this paper to review briefly a few of these experiments which are directly concerned with meteorites, and to point out other ways in which this new knowledge could be used to obtain information concerning the origin and the history of meteoritic bodies.

It is now recognized that these Widmanstätten patterns all arise from solid-metal reactions which operate by crystallographic mechanisms. These mechanisms may be described and specified by the relations which exist between the parent

matrix-lattice and the product or precipitate lattice. The research in question was concerned with two different mechanisms which had been found to operate in the transformation of the face-centered, cubic lattice of γ-iron to the body-centered, cubic lattice of α-iron.[4] Iron-nickel alloys are well suited to such studies because the temperature at which they undergo this γ-α-transformation can be controlled easily in the laboratory. The study revealed that the mechanism proposed by Kurdjumow and Sachs,[5] which gives rise to the relation

(111) γ // (110) α*
[110] γ // [111] α,

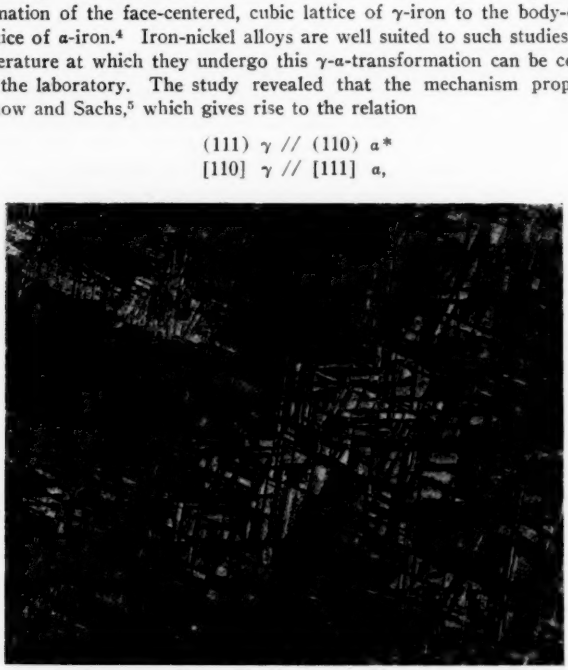


FIGURE 2

THE WIDMANSTÄTTEN PATTERN OF AN AMALIA FARM [= BETHANY, GREAT NAMAQUALAND], SOUTH AFRICA, METEORITE.
Magnification, ×1.

operates when the transformation occurs at relatively high temperatures, about 250° C. in the alloy studied, while the mechanism of Nishiyama,[6] resulting in the relation

(111) γ // (110) α
[211] γ // [110] α,

operates when the transformation proceeds at lower temperatures—that of liquid nitrogen in the present instance.

The coarse lamellae of α-iron in meteorites (Fig. 1), known as kamacite plates, provide an exceptional opportunity for crystallographic study. However, earlier

*This notation indicates that a dodecahedral plane, (110), of the body-centered, cubic α-lattice forms parallel to an octahedral plane, (111), in the face-centered, cubic γ-lattice of the matrix, and that some octahedral direction, [111], in the aforementioned dodecahedral plane, is parallel to a dodecahedral direction, [110] in the octahedral plane of the matrix.

work[7] was not sufficiently accurate to distinguish between the two mechanisms described previously; so new experiments were made on a sample of Canyon Diablo, Arizona, meteorite. These data showed that the high-temperature mechanism of Kurdjumow and Sachs had been effective in this case. This fact in itself seems to establish that the Widmanstätten pattern was developed during slow cooling of the specimen, for very rapid cooling to something approaching liquid-air temperatures would be required to set up the conditions necessary for the operation of the Nishiyama mechanism; in fact, it seems improbable that the mechanism of Nishiyama could operate in an iron of average meteoritic composition of any appreciable size.

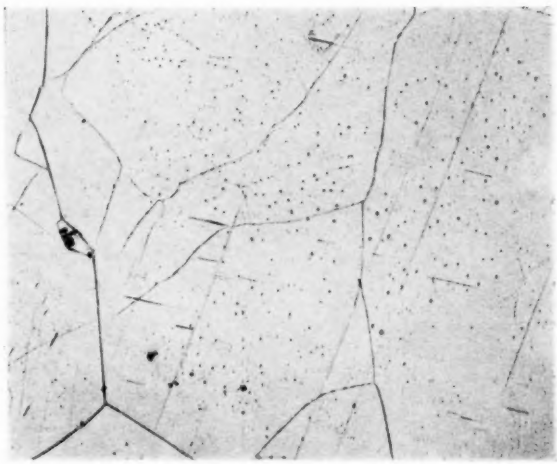


FIGURE 3

A PHOTOMICROGRAPH OF A CANYON DIABLO METEORITE.
Magnification, ×60. Nital Etch.

The faint, long, nearly vertical lines are Neumann bands. The short, nearly horizontal, straight lines are rhabdites. The boundary of a kamacite plate is shown by the irregular line at the left, composed of straight sections. The network of fainter curved lines is veining.

As a natural by-product of these experiments several other interesting observations were made.[8] In choosing a suitable sample for the crystallographic studies, it was found that an Amalia Farm [= Bethany, Great Namaqualand], South Africa, meteorite (Fig. 2), which displayed an exceptionally regular Widmanstätten pattern or macrostructure, was highly imperfect when examined by X-rays. The macro-pattern of the Canyon Diablo sample is comparatively irregular and gross, but X-rays revealed that the lattice of any one kamacite plate was very perfect. Similar observations, that good Widmanstätten patterns are accompanied by irregular Laue spots, had been made on other meteorites by Leonhardt.[9] All of the factors which determine the relations between crystal growth and crystalline perfection are not yet fully understood by metallurgists, and a more intensive study of

these phenomena in meteorites would make valuable additions to our understanding of these factors, as well as to our information on meteorites.

Microscopic examination of the Canyon Diablo samples disclosed a phenomenon that had not been discussed previously, though it is evident in many earlier micrographs, known as veining (Fig). The veins have the appearance of grain boundaries within the kamacite plates. However, the X-ray work already described, the continuity of the Neumann bands visible in the same micrographs, and the regular orientations of the rhabdites throughout these plates, all show that these markings are not grain boundaries but "veins." It is generally assumed that the formation of veins is favored by extremely slow cooling.[10] As in Widmanstätten patterns,

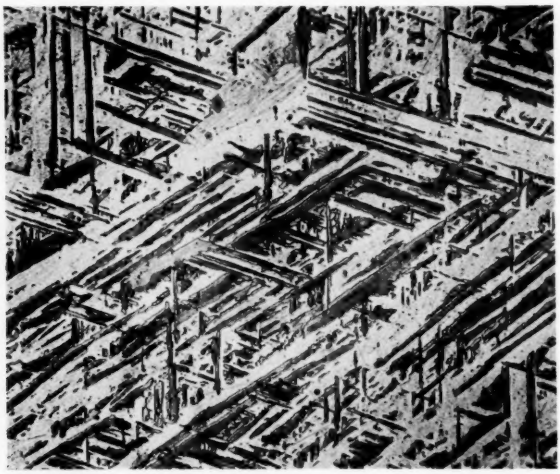


FIGURE 4

THE WIDMANSTÄTTEN PATTERN OF A SLOWLY COOLED ALLOY OF IRON WITH 27% NICKEL.
Magnification, ×50. Nital Etch.

meteorites provide us with examples of veining on a far grosser scale than metallurgists have ever been able to develop in the laboratory. The Neumann bands just referred to are deformation twins, and it is now known that this type of structure can occur in body-centered, cubic lattices only as the result of very rapid deformation. In meteorites, they must have been produced after the transformation which developed the Widmanstätten pattern, either by an explosion of some sort within the body or by sudden impact with some other body. Reference to this matter will be made later in the paper.

After the similarity of the coarse meteoritic Widmanstätten pattern to the microscopic Widmanstätten patterns found in steels was established, the temptation to produce equally coarse specimens in the laboratory became very strong. No difficulty was ever experienced in reproducing the geometry of the figure, but man has thus far failed to attain the huge scale of the pattern found in such meteorites as Canyon Diablo. However, a gratifyingly close approach was made during the in-

vestigations just described (Fig. 4), and this too confirms our belief that the process is completely understood if it is interpreted as a simple allotropic transformation which occurs during slow cooling.

It is regrettable that our modern science of metallurgy, whose pedigree may be traced back to such purely philosophical origins as the phase rule of Gibbs and the study of meteoritic irons by Widmanstätten, has become an extremely practical and utilitarian science. For this reason, it is quite unlikely that present-day metallurgists will devote much of their attention to the study of meteorites, unless some special arrangements are made by a group, similar to the one assembled here, whose primary interest is meteorites and not the tool steel of tomorrow! There-

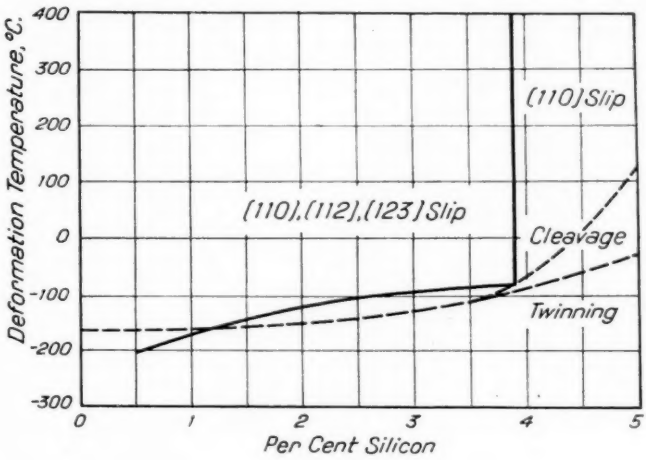


FIGURE 5

SUMMARY OF SLIP, TWINNING, AND CLEAVAGE DATA FOR IRON-SILICON ALLOYS.

fore, it seems worth while to consider the type of information which could be obtained if such research were initiated. It might be pointed out also that similar studies on stony meteorites have already given a great deal of information. The work with metallic meteorites, however, might be expected to be much more fruitful, since it would deal with a relatively simple, homogeneous, and essentially two-component mass, which can be reproduced satisfactorily in the laboratory.

The crystallographic operations involved when a piece of metal is subjected to plastic deformation have been examined extensively. These may be classified conveniently as slip, twinning, and cleavage, and these various forms of deformation can be distinguished by microscopic observations. Recently Dr. C. S. Barrett[11] has demonstrated that a chart for iron-silicon alloys may be drawn which tells just which of these mechanisms shall operate under specified conditions of testing (Fig. 5); *i.e.*, if the composition of an iron-silicon alloy is known and the temperature and rate of deformation are given, one can predict not only which type of deformation will operate, but also the crystallographic planes of the lattice which will be involved. Earlier in this paper the deformation markings known as *Neumann bands* were described. Other types of deformation can be observed in meteorites. If

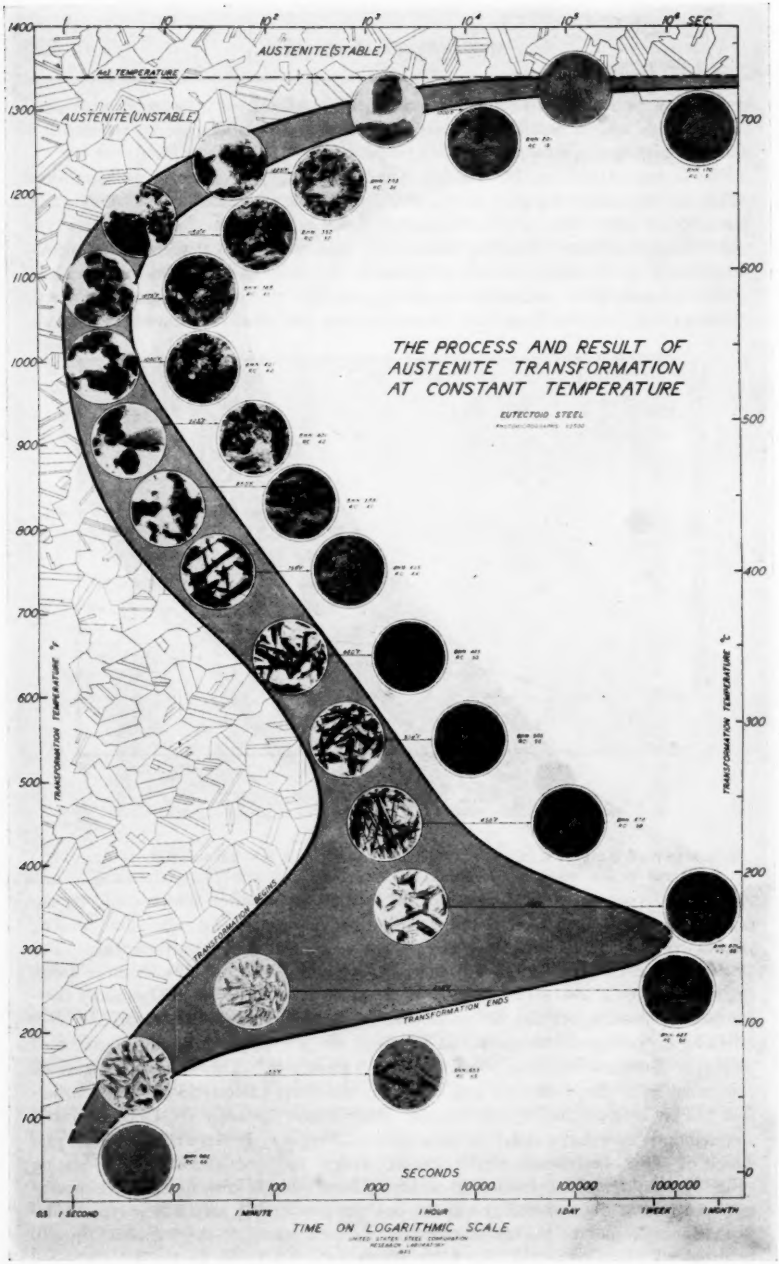


FIGURE 6

THE BAIN "S" CURVE, RELATING THE RATES OF TRANSFORMATION TO THE MICROSTRUCTURES OF A EUTECTOID STEEL.

a chart, such as that which Dr. Barrett determined for iron-silicon alloys, were constructed for alloys of meteoritic composition, very definite conclusions could be drawn concerning the conditions which must have given rise to these markings—*e.g.*, the temperature of the body and the severity of the deformation.

An outstanding contribution to physical metallurgy has been made by Edgar C. Bain[12] in what is now commonly known as the Bain "*S*" curve (Fig. 6). The scientific implications of this curve are numerous and complex;[13] it has changed the heat treatment of steel from the practice of an art to one of science. For our immediate purposes it can be described very simply, however, as a plot against temperature of the time at which the decomposition of an austenitic eutectoid steel shall begin and end. The structures produced by the decomposition also are included as a part of the curve. Not only does the type of reaction, and consequently the product, change with temperature, but also the coarseness of the pattern changes within a temperature range which includes only a single type of reaction; *e.g.*, between 717° C. and 648° C., a lamellar product known as *pearlite* forms by a process of nucleation and growth and the spacing between the individual plates changes from 6.3×10^{-5} cm. at 717° C. to 1.7×10^{-5} cm. at 648° C. At much lower temperatures, the product known as *martensite* forms by a shearing mechanism. If a curve like Bain's "*S*" curve were prepared for an alloy of meteoritic composition, one could determine the temperatures at which the different structures occurring in the meteorite originated. From this determination the rate at which the body cooled could be deduced, and this, in turn, would give information concerning the size of the body when the reactions occurred. Since it seems certain that some of these reactions must have occurred very slowly, diffusion data on such alloys also would be highly desirable and informative. Certainly such quantitative data would remove some speculation from existing hypotheses on the origin and the history of meteorites.

The slow rates at which reactions may occur in the solid state have made the determination of the true equilibrium diagram for the iron-nickel system very difficult. No generally accepted values have yet been obtained for the limits of the α- and β-fields at low temperatures. Important changes have been suggested recently by Owen and Sully,[14] and, if these are substantiated, they should assist materially in the correct interpretation of meteoritic patterns.

In summary, evidence has been outlined which indicates that the reactions producing the coarse Widmanstätten patterns characteristic of meteorites must have occurred at relatively high temperatures during very slow cooling of the body. The additional quantitative information on temperatures of reaction and rates of cooling, which additional metallurgical research on the structures found in meteorites might be expected to yield, also has been reviewed.

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Recording and Designating Meteoritic Falls: Second Note

This communication is intended to supplement and to amend the note that appeared in the *C.S.R.M.*, **2**, No. 1, 64: *P. A.*, **46**, 581-2, 1938. In a private letter dated June 19, 1939, Councilor H. W. Nichols, Chief Curator of Geology, Field Museum of Natural History, Chicago, Illinois, writes: ". . . I feel that there may be some confusion between Greenwich Civil Time (G.C.T.) and Greenwich Mean Time (G.M.T.) and some danger of the inexperienced recording the time as one day too early . . . I approve of the idea [of recording the G.C.T.], although local time also should be recorded." The writer is heartily in favor of Councilor Nichols' proposal and recommends accordingly that both the date and the *Standard Time* (*e.g.*, the P.S.T.), in use at the place of a meteoritic fall, be registered for it. If the Standard Time is given, obviously no ambiguity will result in the date, while the reduction to G.C.T. or U.T. ("Universal Time")—for purposes of permanent record *etc.*—will be a simple matter. However, the writer recommends further that, for the sake of uniformity, in all *catalogs* of meteoritic falls, the G.C.T. or U.T., if ascertainable—rather than some other kind of time—as well as the date, of each *witnessed* fall, be listed by the compiler.

In the earlier note (*l.c.*), it was advocated that each meteoritic fall be designated by the full name of the post office nearest the place of its occurrence, unless no post office is situated within a radius of several miles of the spot, and that, in this case, the name of the smallest political subdivision in which the fall took place, be used in lieu of a post office name. This statement should be amended to read: Each meteoritic fall should be designated by the full name of the post office nearest the place of its occurrence *and in the same political subdivision with it*, unless no such post office exists within a radius of several (*i.e.*, six or eight) miles of the spot; in that case, the name of the best-known, nearby geographical feature in the subdivision, or that of the subdivision itself, should be employed in lieu of a post office name; *e.g.*, "Canyon Diablo, Coconino County, Arizona," "Goose Lake, Modoc County, California" (neither of these falls occurred near a post office), "Ness County, Kansas," and "St. Genevieve County, Missouri." In any event, the name of the fall should include that of the smallest political subdivision (in the United States, commonly the county, if not the town) in which the fall occurred; it should include the name of the nearest post office or permanent landmark, if and only if (as is generally the case) this is situated in the same political subdivision as the place of the fall. To give a fall the name of simply the nearest post office or prominent geographical feature, if—as might happen—this were located in a different nation, state, or even county, from that in which the fall took place, would be manifestly misleading. In a case of this kind, doubtless the name of the smallest political subdivision (*e.g.*, the county) would serve most appropriately as the primary part of the designation of the fall.

That some difficulty may arise in applying the foregoing rule to the cases of meteoritic *showers* that cover a wide area or that extend from one territorial subdivision into another, is anticipated. However, such cases have been and probably

will be so rare, that it is hardly necessary to formulate a specific rule to govern them. Should a case of this kind occur, it would be dealt with best individually.

It is recommended that the practices endorsed in this and in the previous note—with the present modifications—be henceforth observed, in recording and designating meteoritic falls, both single and multiple. To avoid increasing the number of names and references, however, in cases where these practices have not been followed, it is proposed that the designations of all falls *now on record* in standard catalogs, such as Prior's and the Niningers', be retained. Already too many "aliases" exist for a multitude of falls—as is evident from Prior's catalog—to cause anything but added confusion from applying, retroactively, even a more scientific system of nomenclature!

FREDERICK C. LEONARD.

The Seventh Annual Meeting

Attention is called to the announcement in the November issue (p. 508), of the Seventh Annual Meeting of the Society, which will occur on the mornings and the afternoons of December 28 and 29, and the morning of December 30, 1939, in conjunction with the convention of the A.A.A.S., at Columbus, Ohio. Two special features of this meeting are the joint session with Section D (Astronomy), of the Association, and the American Astronomical Society, on "The Spectrographic Study of Meteors and Meteorites," which will take place on the morning of December 30, and the joint session with Section E (Geology and Geography), on the morning of December 29, the papers of which will be of special interest to geologists and meteoriticists. Members will kindly note that the *titles and abstracts* of all papers which are intended to be presented at the meeting should be in the *Secretary's* hands, *not later than November 26*, if the titles are to appear on the printed program.

ROBERT W. WEBB, *Secretary*.

The Meteoritic Shower of 1933 October 9

The results of an investigation as to the number of meteors seen during the meteoritic shower which took place on 1933 October 9 has been published by Professor Pio Emanuelli of Rome in *Coelum*, Vol. IX (1939), pp. 161-164. As is known, the meteors are associated with the short-period comet Giacobini-Zinner.

Using the best data of observation, published in the various astronomical journals, the author has come to the following conclusions:

(1) The meteoritic shower began at $18^h\,10^m$ and ended at $22^h\,0^m$ (Universal Time).

(2) The number of the meteors during 1 minute, at the times indicated below, was:

U.T.	No. per Min.	U.T.	No. per Min.	U.T.	No. per Min.
$18^h\,10^m$	1	$19^h\,30^m$	130	$20^h\,50^m$	48
20	3	40	190	21 0	34
30	7	50	300	10	24
40	13	20 0	350	20	15
50	20	10	330	30	8
19 0	29	20	190	40	4
10	45	30	90	50	3
20	70	40	65	22 0	2

(3) The total number of meteors observed between $18^h\,10^m$ and $22^h\,0^m$ was 19,500. The shower reached the greatest intensity between $19^h\,20^m$ and $20^h\,30^m$

with 15,700 meteors, *i.e.* 8/10 of the entire number. The maximum happened at $20^h\ 4^m$.

(4) The distribution of the meteors observed was:

from	$18^h\ 10^m$	to	$18^h\ 50^m$	300 meteors
	18 50		19 20	1,100
	19 20		20 30	15,700
	20 30		21 10	2,000
	21 10		22 0	400
from	$18^h\ 10^m$	to	$22^h\ 0^m$	19,500 meteors

The author thinks that it is possible that the total number (19,500) of *observed* meteors may be less than the actual number. Supposing that during the interval of the greatest shower ($19^h\ 20^m$-$20^h\ 30^m$) 1/6 of the meteors (of course, the smallest) escaped the observers, the number of meteors between $19^h\ 20^m$ and $20^h\ 30^m$ would be 18,800, and the total number 22,600.

VARIABLE STARS

Variable Star Notes from the American Association of Variable Star Observers

By LEON CAMPBELL, Recorder

Another Recurrent Nova: To the small list of novae which have been known to present two or more outbursts we can now add another, Nova (U) Scorpii, 1863, which Mrs. H. L. Thomas of Harvard Observatory found to be again at maximum, in 1906 and 1936. The star was originally discovered by Pogson on May 20, 1863, and was observed at maximum at magnitude 9.1; eight days later the star had decreased to magnitude 12.4. Mrs. Thomas found the nova to be bright, at photographic magnitude 8.8, on May 12, 1906. It was again at maximum, magnitude 8.8, on June 22, 1936, and one month later had faded away to magnitude 15.2. During the intervals between maxima the star was exceedingly faint, below magnitude 17.6.

Other well-known recurrent novae are Nova (T) Pyxidis which has presented at least three maxima, (1890, 1902, and 1920) and Nova (RS) Ophiuchi, (1898, 1933). Another possible recurrent nova is that discovered in Orion (1677) which seems to have had two subsequent outbursts, one in 1750 and another in 1892. If we list the intervals of these recurrent novae, we find these intervals to range from 12 to 142 years. The following table gives years of appearance, observed limiting magnitudes and intervals in between appearances for these four recurrent novae.

Nova Ori				Nova (T) Pyx				Nova (RS) Oph				Nova (U) Sco			
Year	Mag.		Int.	Year	Mag.		Int.	Year	Mag.		Int.	Year	Mag.		Int.
1677	7	—	73	1890	8	14	12	1898	[9-12		35	1863	9-	12	43
1750	7	[11	143	1902	7	14	18	1933	4-12			1906	9-[17		30
1892	6	—		1920	6	[13						1935	9-[17		

Nova (T) Pyxidis and Nova (RS) Ophiuchi have been assiduously followed since their last maxima and no indication of additional outbursts have been found to date. The former has not been seen brighter than magnitude 13 since 1920, and

on the few occasions when it has been seen, the recorded magnitude is around 14. RS Ophiuchi has varied somewhat irregularly between magnitude 10.5 and 12.0 since the minimum was last attained early in 1934.

From observational evidence at hand it is found that the recurrent-type novae appear to have very sudden increases to maximum, followed by relatively rapid decreases to minimum. The 1933 observed maximum of RS Ophiuchi occupied barely three months in going from minimum to maximum and back to minimum. The 1902 maximum of T Pyxidis lasted approximately four months. Examination of the light curves of U Scorpii shows that the 1936 maximum was of even shorter duration than that of RS Ophiuchi in 1933. It might be well for observers to watch closely other well-known novae which have had single outbursts lasting only a few months, some of which are listed in the next table.

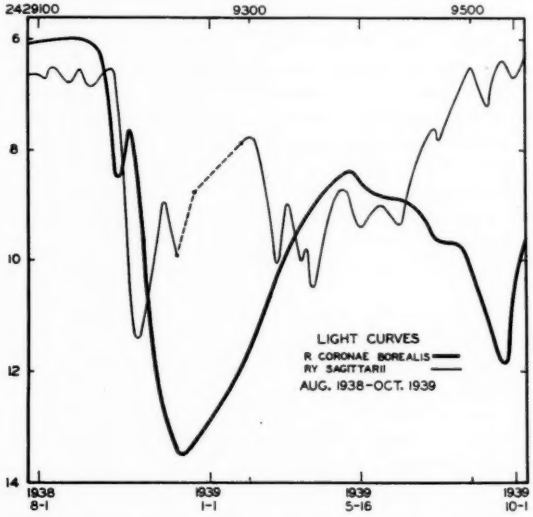
Design.	Name		Magnitudes Max.	Min.
051316	Nova (XX) Tau	1927	*6.0*	[*16*
1811*23*	Nova (FM) Sgr	1926	*8.6*	[*16*
1915*00*	Nova Aql	1899	*6.8*	[*15.4*
200317	Nova Sge	1913	*7.2*	[*16*

Current Data on Special Variables: Since the year 1935 some forty to fifty additional variables have been added to the AAVSO observing program. Some of these were regular long-period variables for which added material was much needed; others were of variables of doubtful and special types. In the past four years the greater number of these stars have been sufficiently well observed to give a check-up on visual range, period, etc. Some radical differences are found to exist between previously published and recently observed facts. These data are presented in the following table, which gives, besides the designation number and name of each star, the limiting observed magnitudes and the approximate period, derived from the visual observations covering this interval of time. These are followed by published data found in Schneller's Catalogue of Variable Stars for 1939; magnitudes at maximum and minimum, period and spectral class. Italics in the magnitude columns taken from Schneller indicate photographic magnitudes.

Design.	Observed Name	Max.	Min.	Approx. per.	Schneller Max.	Min.	Per.	Spec.
000451	SS Cas	9.0	13.2	142[d]	8.5	[12.0	142.5	M3e
020448	RV And	9.4	10.9	172?	9.1	10.3	229	M3e
024136	TX Per	9.0	12.0	77	9.5	12.3	77	Mp
024217	T Ari	8.2	10.8	328	7.4	10.8	313.6	M6
032339	RU Per	10.0	11.9	318	9.0	10.8	180.7	M4
052372	RR Cam	9.6	10.8	360?	9.9	11.3	123	G?
055646a	RS Aur	9.5	11.6	173	9.4	11.4	174.0	M3
055646b	SV Aur	9.4	9.9	Irr.	9.4	9.7	..	K?
062105	SW Mon	9.1	10.5	105?	*10.8*	*11.8*	..	M2
065326	SW Gem	8.6	10.0	..	9.2	10.6	680	K0
065530	RS Gem	10.1	11.5	..	9.5	10.9	151.6	..
073520	Y Gem	9.0	10.0?	..	8.5	13.5	Irr.	M6e
080165	RZ UMa	8.4	9.7	255?	8.8	10.2	..	M7
081633	T Lyn	9.0	13.0	410	8.0	12.0	419	N0e
090151	V UMa	9.9	11.1	Irr.	9.6	11.2	207.5	M3
094735	S LMi	8.5	14.0	230	*8.5*	*11.*	234	M3e
094836	U LMi	10.6	12.9	277	*11.4*	*13.0*	178	..
0954*58*	RR Car	7.2	8.5	Irr.	*8.1*	*9.6*	Irr.	M6
095814	RY Leo	9.0	11.6	155	8.7	11.5	155.2	M2
102900	S Sex	9.0	13.5	265	9.2	11.7	267	M2e

Design.	Observed Name	Max.	Min.	Approx. per.	Schneller Max.	Schneller Min.	Schneller Per.	Spec.
115158	Z UMa	6.8	9.0	190	*8.4*	*10.2*	198.0	M6e
131546	V CVn	7.0	8.2	188	6.4	8.9	191.5	M5e
164403	TT Oph	9.3	11.0	30	8.8	11.0	61.1	F8pe
165905	TX Oph	9.9	11.2	72	9.6	11.2	138	M0
180222a	VX Sgr	8.2	11.0	680	7.9	11.8	731	M4e
181031	TV Her	9.4	14.5	306	9.1	15.	308	M4e
203422a	RU Vul	9.0	11.7	155	8.5	10.8	158.3	M3e
211614	Y Pav	5.3	6.9	225?	*5.7*	*8.5*	..	N0
220843a	RS Lac	10.2	12.2	235	9.3	12.8	237.4	K0
220843b	RY Lac	10.9	11.8	Irr.	11.4	12.7	122	..
225342	TV And	8.7	10.9	113	8.6	10.8	114.8	M4
225542	SZ And	10.3	14.3	342	10.1	[14.5	342.0	..
230140	TY And	8.9	10.5	265?	8.9	10.2	..	M4e
231539	RY And	10.0	14.0	400	10.	[13.	399.7	..

For RS Geminorum a period of 151 days appears not to hold. A period of 207 days for V Ursae Majoris is not confirmed. There is a suggested long period of 700 days for RR Carinae, with intermediate periods. Z Ursae Majoris has irregularities in form of curves, but they do not resemble those of RV Tauri. A period of 30 days appears to be evident for TT Ophiuchi, although there are irregularities manifested. For TY Andromedae a period of 265 days seems to be indicated, with an apparent secondary maximum.



1938-39 Minima of R Coronae Borealis and RY Sagittarii: The accompanying figure represents the smoothed curve light variations of R Coronae Borealis and RY Sagittarii as observed by the AAVSO from August, 1938, to October, 1939. The former is indicated by the heavy curve and the latter, by the light curve. The short-term periodicity of 38.6 days in RY Sagittarii noted some years ago by L. Jacchia is fairly well indicated—see these notes for last month.

The Recent Bright Maximum of Z Andromedae: In Variable Star Notes for October attention was called to the increase in light of Z Andromedae. Since that note was written the variable has continued to increase steadily in light to visual magnitude 7.9, the brightest ever recorded. The brightest photographic magnitude was 9.4, attained in 1914.

The spectrum of the star was photographed at the McDonald Observatory on September 14, 1939 (JD 2429521), and found to be completely different from the spectra studied by H. H. Plaskett in 1923-1927 when the variable had a visual magnitude of about 9.6. When photographed at the McDonald Observatory the variable was of visual magnitude 8.2, probably near maximum. The Balmer lines showed the typical structure found in P Cygni, which reached third magnitude in 1600 and at present is about the fifth magnitude, and, though perhaps not a typical nova, may be allied to that class.

Z Andromedae, according to Plaskett, has a spectrum which is composite; a stellar part, which consists of a strong continuous spectrum with numerous narrow emission lines projected thereon, and a second part which is nebular in character and arises from an extended surface which in itself is apparently variable in extent. The stellar part arises from the "Z Star," and the nebular part from the "Z Nebula" which, he deduces, has a total magnitude approximating 15. Plaskett suggests that there is a physical association between the "Z Star" and the "Z Nebula."

F. H. Hogg, in 1932, showed conclusively that the spectrum of Z Andromedae also contained titanium oxide bands and that the spectrum had strong similarities to several M stars. The system appears therefore to consist of a third component, a late-type star, besides the early-type star and nebula. It has been suggested that the nebula may be the atmosphere of the M star.

Because the early discovery spectrum of Z Andromedae resembled that of a nova, the star has, by some authorities, been classified as a nova or nova-like variable. Perhaps it should more properly be classified as a nebular variable, the most outstanding star of that class being R Aquarii. Dr. Prager found strong indications of a 640-day period for the fluctuations in Z Andromedae, although the present maximum followed that of 1938 by only one half of this amount.

Observers and Observations, October, 1939:

Observer	Var.	Est.	Observer	Var.	Est.
Albrecht	69	78	Evans	44	53
Armfield	2	2	Ferguson	8	11
Baldwin	35	53	Fernald	128	185
Ball, A. R.	25	25	Ford	29	31
Ball, J.	30	31	Franklin	29	44
Blunck	31	31	Grater	2	2
Bouton	26	34	Gregory	107	149
Brocchi	54	111	Griffin	4	4
Buckstaff	25	83	Halbach	120	178
Callum	41	50	Harris	40	40
Cameron	8	8	Hartmann	168	237
Carpenter	6	6	Hayner	2	2
Chandra	71	123	Hiett	9	19
Christman	36	38	Hildom	15	20
Cilley	30	50	Holt	62	92
Cousins	38	103	Houghton	61	145
Dafter	7	24	Houston	169	700
Diedrich	29	38	Howarth	14	14
Economou	13	15	Jones	83	278
Ensor	43	48	Kearons	51	109

Observer	Var.	Est.	Observer	Var.	Est.
Kelly	27	52	Ryder	10	10
Kozawa	4	24	de Santis	6	9
Laskaris	1	3	Schmid	11	11
Livingston	7	7	Schoenke	17	23
Loreta	185	542	Shafer	4	6
Lovinus	8	8	Shultz	15	15
Lundquist	31	44	Sill	83	83
MacPherson	14	22	Smith, C. W.	1	2
Meek	45	459	Smith, F. P.	13	13
Moore	8	11	Topham	64	85
Needham	24	30	Treadwell	15	18
Palo	20	50	Varela	10	22
Parker	38	38	Walton	12	35
Peltier	35	168	Webb	31	31
Prinslow	10	11	Weber	41	41
Purdy	11	21	Williams	9	37
Pursell	5	5	Yamada	8	36
Rosebrugh	12	53	Yamasaki	23	23
de Roy	18	55			
Russell	23	63	78		5500

November 7, 1939.

Notes from Amateurs

The New Haven Amateur Astronomical Society

The New Haven Amateur Astronomical Society at a well-attended meeting on October 28 admitted five new members and listened to a very fine report given jointly by Dr. and Mrs. Rademacher of the recent A.A.V.S.O. convention in Boston. Mr. A. B. Heller addressed the society on the subject, "The Contribution of French Scientists to Astronomy," and said in part, it was in France that the length of an arc of the meridian was first measured. Picard made the earliest observations of the celestial bodies by employing telescope sights. He made observations of the meridional altitude of the sun in the garden of the Royal Library of Paris with a quadrant of 9 feet, 7 inches, and a sextant of 6 feet, both furnished with telescopes. Lacaille in 1750 amassed material for determining the parallaxes of the moon, Venus, and Mars.

The Academy of Science of Paris offered a prize in 1748 for a complete investigation of the inequality of the long period in the mean motions of Jupiter and Saturn. The planets while revolving around the sun disturb each other by their mutual attraction and hence arise numerous inequalities in their motions similar to those which take place in the motion on the moon around the earth. Laplace investigated the subject and found that from the time of the earliest astronomical observations, the mean motions of the planets have not been altered by their mutual attraction and he inferred that the irregularities of Jupiter and Saturn must be attributed to some disturbing cause independent of that principle. This result was decisive in so far as the question relative to the irregularities of Jupiter and Saturn were concerned but it still remained uncertain whether an inequality of this kind might not exist among the terms involving the higher powers of the eccentricities and inclinations. Such an inequality, however minute, would ultimately become considerable by continual accumulation and might affect the mean motions and the

mean distances of the planets to so great an extent as to occasion the total derangement of the planetary system. Lagrange in 1776 investigated this important question and arrived at a remarkable conclusion. The eccentricities and inclinations will perpetually vary in magnitude; the apsides and nodes will similarly vary in position, but throughout an indefinite lapse of ages the mean motions of the planets will remain unaltered by their mutual attraction. This is one of the most valuable truths we have which shows us order in the heavens controlled by laws.

Laplace in announcing his famous nebular hypothesis of the origin of the Solar System said, "We are astonished to see all the planets move around the sun from west to east and nearly all in the same plane, all of the satellites moving around their respective planets in the same direction and nearly in the same plane with the planets. The sun and planets also rotate on their axes in the same direction from west to east. A phenomenon so extraordinary is not the result of chance, it indicates a universal cause which has determined all these motions." Thus Laplace reached his conclusion by reasoning backward from the remarkable coincidences in the planetary system. The cause of these must have been a fluid of immense extent. To have given in the same direction a nearly circular motion around the sun the fluid must have been a kind of solar atmosphere which originally extended far beyond the limits of the present solar system. As the atmosphere or nebula contracted the planets were formed by the condensation of zones, while the satellites were formed in a similar way.

While Laplace's hypothesis was faulty in detail the nebula theory is valid in its main presupposition that the solar system has developed in the course of centuries from the simple to the complex, from diffuse dust cloud of the immeasurable distant past to the sun and planets as we know them today.

Mr. Heller's talk was very instructive and much appreciated by the large attendance present.

F. R. BURNHAM, *Secretary.*

November 10, 1939.

The Cleveland Astronomical Society

The annual business meeting of the Society was held at the Warner and Swasey Observatory, at which officers were elected for the year 1939-40 as follows: President, Dr. J. J. Nassau; Vice-president, Mr. James L. Russell; Secretary and Treasurer, Mrs. Royce Parkin; Recording Secretary, Mr. Don H. Johnston; Executive Committee, Dr. O. L. Dustheimer and Dr. S. W. McCuskey, and the above officers; Nominating Committee, Mrs. H. T. McMyler, Miss Helen Focke, and Mr. George Hale. This meeting was held on October 5.

The first regular meeting and lecture was on "Astronomical Activities on the West Coast" by Dr. J. J. Nassau, Director of the Warner and Swasey Observatory, Case School of Applied Science. The attendance was good as usual and the subject of great interest to all owing to the great activity on the west coast in connection with the 200-inch reflector under construction.

At the second meeting on November 10, we had Dr. J. A. Hynek of the Perkins Observatory as lecturer, his subject being "Astronomy versus Astrology." He showed us graphs involving 20,000 individual men of science and applied mathematical formulas which showed astrology as a superstition and not a science. If the claims of astrologers were supported by scientific proof, he said, the intellectual attainents of these men would necessarily place their birth dates predominantly under the favorable influence of Mercury, the planet which, according to astrologers,

governs the capacity of the intellect. Statistical results, however, "show that nothing whatsoever favors one day of birth over another so far as intellect is concerned," he said. He intimated that, although there was a great deal of charm in a study of ancient astrology, the same could not be said of the modern versions. Apparently there are more than twelve magazines published in the interest of astrology in the United States alone. There were several astrologers present who did not seem to agree with our speaker which added spice to the meeting.

Euclid Beach Park, Cleveland, Ohio. DON H. JOHNSTON.

Physical Conditions upon the Planet Venus

Between November, 1935, and November, 1937, a period of two years, the author observed the planet Venus more or less regularly at Mount Union College Observatory with the 10-inch refracting telescope. A total of one hundred and twenty drawings was made. Magnifications employed were chiefly 130×, 160×, and 230×. Venus was not continuously observed during the above-mentioned period; and the best work was done in May, June, and July, 1937. When results were tabulated and analyzed, the author found it possible to set forth a picture of physical conditions upon the planet Venus. Very possibly this picture will require later revision, for the observations of no single observer are infallible. Nevertheless, science progresses by the advancement and discussion of theories; and the author will welcome criticism of his present views of physical conditions upon the planet Venus, which views are set forth here.

The author is of the opinion that the planet always keeps the same face sunward; in other words, that Venus rotates in 225 days, the period of revolution. Although Schiaparelli, Lowell, and Antoniadi support such a rotation-period, other equally skilled observers favor a shorter one. The author bases his opinion upon the persistent visibility of some marks in the same positions week after week and even month after month. Successive drawings a few days apart are similar, and even those several weeks apart often show marked resemblances. The best example is that of a large roughly triangular area seen upon the terminator at western elongation. This area is shown distinctly on every drawing between May 17 and August 13, 1937, inclusive, and is more or less definitely depicted on some September drawings. This area was also drawn by the author in November, 1935; and Ed Martz of Chicago independently observed it in October, 1935. Numerous other examples of stability of certain detail over long periods of time could be given. Another observation gives the 225-day period indirect confirmation. For if Venus always keeps the same face sunward, we might expect the region around the subsolar point, the point on Venus directly under the sun, to be rather cloudy and detail in this region to be vague. This region occupies the central portions of the disk when Venus is near the full phase, and indeed it is found near the full phase that detail in the center of the disk is very vague, more so than detail on the limbs. At other phases the limb detail is much vaguer than the central detail and ought to be so, for we are looking into more Venusian atmosphere on the limb than at the center of the disk. The atmosphere around the subsolar point must, then, be appreciably denser than in those regions well removed from this point.

Most of the phenomena seen upon Venus are associated with the presence of a rather dense atmosphere, and such a condition is consistent with our present views about Venus.

Some observers consider that the cusps of Venus are brighter than the disk; and others that they are dimmer than the disk. The author has seen both appearances. It is true that when Venus is a very thin crescent, the cusps seem to be dimmed as a result of phase. At other phases, however, the cusps vary; sometimes one is brighter than the other; sometimes both are like the disk; sometimes both are brighter than the disk. The variations are rapid and irregular. These cusp-areas represent, in the author's opinion, polar cloud-caps upon Venus.

When we look at the limb of Venus, we are looking into a relatively great thickness of Venusian atmosphere, as noted above. We might accordingly expect to find atmospherical phenomena upon the limb. We do indeed find that the limb is brighter and whiter than any other part of the disk (except perhaps the cusps) and that any dark marks upon the limb are very vague. We learn, upon the assumption of a 225-day rotation, that the aspect of a portion of Venus when upon the limb is a totally unreliable indication of what its appearance will be when it is more centrally placed. The limb is not usually uniform in brightness but can be broken up into separate bright areas or bright spots. In January and February, 1936, the author saw small bright spots on the limb which suggested by their appearance that they were elevated above the limb. Wolf Spangenberg of Germany has observed similar spots. These spots certainly look as though they were clouds very high in the Venusian atmosphere. The limb areas are probably subject to rapid and irregular changes in brightness. Sometimes the south limb is brighter than the north limb; sometimes the reverse is true. In the autumn of 1937, the author saw a dark linear mark bordering the limb. Although this mark was often the darkest one on Venus, it must have been a contrast-effect; for it kept following the bright limb region westward as the phase increased. This observation suggests that some of the other dark marks on Venus seen by both the author and others may be effects of contrast.

The chief detail the author sees on Venus, apart from the bright regions on the limb and at the cusps, consists of dark arc-like markings, that on some drawings almost resemble Lowellian *canali*. Similar dark markings are seen by many other observers, although individual styles of depicting such detail differ considerably. The author is inclined, basing his opinion upon the permanency of such details, to think that such dark detail may be permanent surface features of Venus. We have, however, already seen that dark detail may be a result of contrast with adjoining bright areas. Moreover, on April 17, 1937, when only a thin shell of atmosphere above the south rim could be seen, dark detail was seen and was certainly of an atmospherical nature; and yet such dark detail was exactly like the dark detail seen at larger phases. Although it is difficult to recognize the exact extent of errors of observation on individual drawings, it is probable that these dark areas are subject to rapid and irregular changes. As with the cusps and the limb, no seasonal dominancy of either the northern or southern hemisphere can be found. The same permanency of dark detail that led us to deduce a 225-day rotation period argues strongly for these marks being surface features, but probably their aspect is influenced by the overlying obscuring atmosphere.

The axis of Venus stands sensibly perpendicular to the plane of the orbit. It is the author's opinion that the angle between the equator of Venus and the plane of the orbit cannot exceed five degrees. We have noted the absence of any seasonal changes and have seen that the variations in cusps, limb, and dark marks are all non-seasonal and are rapid and irregular, being best explained by clouds. But if

the axis of Venus deviated as much as ten degrees from perpendicularity to the orbit-plane, not only would seasonal effects probably be produced, but also there would be an up-and-down shift of detail through an arc of twenty degrees during the course of the Venusian year. No such shift has been observed.

The best-known and most frequently observed effect of the atmosphere of Venus is to prolong the cusps. This cusp-elongation delays observed half-phase until the theoretical phase is well beyond half. In the summer of 1937 observed half-phase did not arrive until K, the quantity indicating what proportion of the disk is illuminated, was equal to .57. Latimer J. Wilson found a similar value for K at observed half-phase in January and February, 1937. The prolongation of the cusps at theoretical half-phase amounted to about nine degrees.

Irregularities are frequently seen upon the terminator of Venus. The author perceived such irregularities regularly between June 8 and July 8, 1937. They may have been to some extent a result of contrast with unusually dark marks then on the terminator. Somewhat similar phenomena seen occasionally upon Mars have been ascribed to clouds, and the author favors the same explanation for these Venusian marks. He is of the opinion that unusually high clouds are illuminated while the regions below them are in darkness. This appearance is naturally seen best near half-phase, for at other phases fore-shortening tends to conceal the irregularities of the terminator.

WALTER H. HAAS.

Mount Union College, January 23, 1938.

Communications and Comments

Under this heading we shall publish from time to time such material as does not properly fall under any of the established headings of this journal. Here, too, may be found, when occasion arises, articles which the editor may not be willing to give sanction to but which, nevertheless, may be provocative of thought along new lines.

The Dog Star and Its Unique Companion

On a clear night in early November, look toward the eastern horizon around midnight, and you will see there one of the most wonderful stars visible from the earth. It is Sirius, the Dog Star, which rises soon after Orion. One scarcely needs to know the position of this star to recognize it, for it is the very brightest star in the sky. Who has not noticed its bluish-white brilliance sparkling forth on a clear winter night? It has been the inspiration of poets from time immemorial. Manilius characterized its beauty in fitting words: "All others he excels; no fairer light ascends the sky, none sets so clear and bright."

Sirius is so bright that its luminosity exceeds that of even the first magnitude stars. Astronomers designate it as having a magnitude of —1.58. The reason for its great brilliance is primarily its nearness to the earth. At a distance of slightly over 8½ light years, it is the closest of all the stars visible in northern latitudes. There are many stars larger than Sirius, but they are so far away that they appear small in comparison. Light travelling 186,000 miles per second takes nearly 22 years to reach us from Vega, the second brightest star in the northern hemisphere, while that of Sirius takes not quite a decade. Compared to our sun, however, Sirius is immense. It is 27 times as bright, 2½ times as heavy, and has nearly

twice the diameter. When seen through a large telescope, the view of Sirius is comparable to a dazzling sunrise, and when its direct light is focussed by the lens, even an experienced eye cannot view it for long. Should the sun and Sirius suddenly exchange positions, the sun would appear a little brighter than Polaris, while Sirius would promptly burn us all to a crisp!

All through history Sirius has attracted the attention of man. The ancient Egyptians worshipped the star, not only because of its beauty but also because it rendered an invaluable service. Its rise in the east in the fall warned them of the approaching overflow of the Nile, and enabled them to prepare for the inundation. Possibly it was this fact that first gave it the name "Dog Star," for like a faithful dog it warned them of approaching danger. The term "Dog Days" is likewise associated with Sirius. During the summer months the Dog Star is above us during the day, and it was believed by the ancients that its light combined with that of the sun to cause the excessive heat of July and August.

Sirius has for many years been an object of great interest to astronomers, not only because of its size and brightness, but also because of its irregularities of motion. It was in the beginning of the 19th century that scientists first began to notice its movements. The fact that puzzled them was not that it moved, but that it moved with so irregular a motion. Instead of moving along steadily it swayed to and fro periodically. No other star was known to behave in such an unusual manner. Naturally astronomers were eager to find the cause, but at that time a serious obstacle confronted them. There were no telescopes adequate to the problem. While an instrument was being constructed, the problem was attacked mathematically. In 1844 Bessel announced that the cause for the irregular motion of Sirius could be explained only if it had a small, but heavy, companion which moved around it once every 50 years, and persistently pulled it out of place.

Just eighteen years later the telescope was finished. It had been constructed by Alvan Clark, of Cambridge, Massachusetts, and had a lens of 18 inches aperture. Clark at once turned it on Sirius, and immediately noticed the faint companion which Bessel had predicted. Not only had the mathematician's prophecy of a companion star been proved, but it has been since ascertained that he was also correct in his prediction of the 50-year cycle. Thus for the first time in history the existence of a faint companion to a large star was determined by computation before it was observed.

Since its discovery this small companion of Sirius has been continually giving us proof that it is perhaps the most remarkable star in the universe. Its unusual properties are due to the star's abnormal density. Astronomers had early predicted that it must consist of very heavy material to be able to pull such a large star as Sirius around with it. Surely a star, which is only one ten-thousandth as bright as its larger companion, and twenty times farther away from it than we are from our sun, must be very heavy indeed, they surmised. But the density which the star really proved to have exceeds their wildest speculations. It was found that every cubic inch of the tiny star's matter weighs one ton! This means that it has a density 27,000 times that of water, 3000 times that of gold, and 2000 times that of platinum. Nowhere else in the universe has material been found which even approaches such enormous density.

This small star is just three times the size of the earth, yet it has a mass 250,000 times as great. If a man of average size were transported there he would weigh about 2600 tons. Indeed, should this account be written on a very thin slab of such material, you would not be able to read more than the first page, for it

would require a 400-pound lift to turn to page two.

The following comparison of relative densities has been made by Dr. W. J. Luyten: "A cubic yard of star mass similar to that of the star Betelgeuse in Orion weighs one-thirtieth of an ounce. A cubic yard of air such as we breathe weights two pounds. A similar amount taken from the sun weighs about a ton. A cubic yard of material taken from the companion to Sirius weighs more than 40,000 tons."

Proof that such enormous density exists was made just fifteen years ago. In 1924 Professor Eddington came to the conclusion that the excessively high temperatures in the interior of stars are able to pack atoms into much smaller space there than on earth. Even on the terrestrial planet, where we live, the size of an atom of hydrogen (of which Sirius' companion is made) is about four one-billionths of an inch. That is, if we line up four billion atoms side by side, we will have a bar of hydrogen an inch long.

Eddington's theory was further verified by Einstein, who added a second hypothesis in his relativity theory, *viz.*, that light waves coming from so dense a star would be considerably lengthened. The same year that Eddington announced his theory, Dr. Adams of the Mt. Wilson Observatory discovered that light waves from the star acted in exactly the manner which Einstein predicted. His observations were made through the 100-inch telescope. A 200-inch telescope is now being constructed in California, which will be completed in two or three years. With the aid of this instrument a more nearly complete knowledge of Sirius and its unique companion can be obtained. The possible discoveries which the Mt. Wilson astronomers will make are awaited with the keenest anticipation by every star lover.

ALVADEE E. HUTTON.

Temple University, Philadelphia, Pennsylvania.

General Notes

Dr. Ralph Allen Sampson, Astronomer-Royal for Scotland from 1910 to 1937, professor of astronomy at the University of Edinburgh, died on November 10 at the age of seventy-three years. (*Science,* November 17, 1939.)

Dr. H. Spencer Jones was elected President of the British Horological Institute, in succession to the late Sir Frank Dyson, at the Annual General Meeting held on Wednesday, October 11. (*The Observatory,* November, 1939.)

Mrs. E. A. Fath, wife of Professor E. A. Fath, director of Goodsell Observatory, died at the Northfield City Hospital, after a brief illness, on Sunday, November 26.

Meeting of Amateur Telescope Makers

At the invitation of Professor Charles H. Smiley, more than sixty amateur telescope makers from all parts of New England attended a Symposium on Telescope Testing held at Ladd Observatory of Brown University on Saturday afternoon, October 21, 1939. The following talks made up the program:

The Foucault Test of Mirrors and Lenses, by Leland S. Barnes; The Foucault

Test applied to the Joseph Brown Gregorian Reflector, by Ernest R. Hager; Hartmann's Method of Testing Telescopes, by Dr. Alice Farnsworth; Testing Schmidts and Schwarzschilds, by Dr. C. H. Smiley; Remarks on Testing Telescopes, by A. W. Everest; Figuring Mirrors by Aluminizing, by Dr. A. B. Focke.

After a picnic supper, the visitors divided into two groups, one discussing color photography and its astronomical applications, and the other tested a number of paraboloidal mirrors under the direction of A. W. Everest.

Book Reviews

The Glass Giant of Palomar, by David O. Woodbury. (Dodd, Mead & Company, New York. 368 pp.; $3.00.)

This is a book which will interest a wide circle of readers—not only those astronomically minded but also those who enjoy a tale of man overcoming great obstacles and doing the seeming impossible. In this story of the 200-inch telescope the author starts with the early life of George E. Hale; his interests as a boy and the manner in which the boy became in time one of the world's foremost scientists. This involves the story of the Yerkes and Mt. Wilson observatories and the efforts Hale made to secure ever better and more powerful equipment until he succeeded in getting the 200-inch project well along toward completion before his passing. He tells the story of efforts to secure a quartz disk; the decision to try glass; the many griefs of the Corning Glass men before they succeeded; how and why Mt. Palomar was selected as the site; how a truck driver became the head optician of the great project; how the design of the mounting evolved, etc. The author gives not only the facts but the drama which lies behind them. Don't fail to read it.

E.A.F.

Lange's Handbook of Chemistry, Third Edition, (Handbook Publishers, Inc., Sandusky, Ohio. $6.00.)

This comprehensive and hence very useful handbook has been issued this year in the third edition. This new volume is considerably larger than those of earlier editions, and it would be difficult to think of any phase of chemical data which is not included in its 1850 pages. There are six new tables added, and eleven tables, given in the second edition, have been extended or completely rewritten. The total number of tables is 168. This volume, however, is not limited to facts in the science of chemistry alone, as its title might indicate. For example, the last two hundred pages are devoted to mathematical tables of various kinds so that the student of mathematics as well as the student of chemistry would do well to have a copy of it at hand.

It might seem that so many pages would make a clumsy and unwieldy volume, but in this instance it is definitely not so. A good quality of thin paper is used, and the binding is a rich green flexible fabricoid.

This volume, therefore, has the following decidedly commendable features: it is up-to-date, accurate, comprehensive, conveniently arranged, easily handled, and ornamental.

POPULAR ASTRONOMY

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